**Regional Municipality of Hamilton-Wentworth**

# TRANSPORTATION ENERGY MANAGEMENT STUDY

# FINAL REPORT

April 1982

IBI Group

# HAMILTON-WENTWORTH TRANSPORTATION ENERGY MANAGEMENT STUDY

FINAL REPORT

IBI GROUP

APRIL 1982

IBI Group

156 Front Street West
6th Floor
Toronto, Canada
M5J 2L6
Cable Address: IBIGRP
(416) 596-1930

April 28, 1982

Mr. J. G. Hindson, P. Eng.
Chairman
Region of Hamilton-Wentworth
  Transportation Energy Management Steering Committee
City Hall
Hamilton, Ontario

Dear Mr. Hindson:

Transportation Energy Management Study
Final Report

Please find attached the Final Report for the Transportation Energy Management Study for the Regional Municipality of Hamilton-Wentworth. We trust that you will find this document, as well as the technical support documents which have been forwarded as Interim Technical Memos, of assistance in the development and updating of a Transportation Energy Management Program.

We have had excellent cooperation from Municipal and Provincial staff which has made the project enjoyable and added to the quality of the final product.

Yours truly

IBI GROUP

Neal A. Irwin
Managing Director

Scott E. Stewart
Senior Associate

SES/jt
Encl.

## ACKNOWLEDGEMENT

This study was funded by the Regional Municipality of Hamilton-Wentworth, the Ontario Ministry of Energy and the Ontario Ministry of Transportation and Communications.

A Steering Committee which was established to provide direction and input to the project consisted of:

Mr. J. G. Hindson, City of Hamilton Traffic (Chairman)
Mr. H. L. Solomon, City of Hamilton Traffic (Secretary)
Mr. R. J. Desjardins, City of Hamilton Traffic
Mr. H. O. Schweinbenz, Region of Hamilton-Wentworth Engineering
Mr. G. S. Aston, Region of Hamilton-Wentworth Engineering
Mr. W. H. H. Smith, Hamilton Street Railway
Mr. A. Gretzinger, Town Engineer, Stoney Creek
Mr. W. G. Cottrell, City of Hamilton Parking Authority
Mr. R. A. Ballantine, MTC Policy and Development
Mr. J. C. D. Patriarche, Ministry of Energy

The consultant would like to acknowledge the special assistance of Mr. J. Hindson and Mr. H. Solomon, who in addition to their project management responsibilities provided valuable technical advice.

TABLE OF CONTENTS

TABLE OF CONTENTS

# EXECUTIVE SUMMARY

## INTRODUCTION

Because of the increasing concern regarding the availability and cost of petroleum energy, there has been considerable emphasis placed on reducing petroleum consumption, particularly in the transportation sector. While petroleum fuels are used by marine, air and rail modes, automotive or road transportation is the dominant user, accounting for approximately 85% of the total transportation fuel consumption. Thus urban transportation is a prime target for efforts to conserve energy.

In Ontario, the Province has adopted energy conservation objectives for the transportation sector. These objectives are:

- for passenger transportation to reduce the fuel consumed per person kilometre by 33% between 1980 and 1995;
- for freight transportation to reduce the fuel consumed per tonne-kilometre by 20% between 1980 and 1995.

The objective of this study was to review relatively inexpensive transportation management measures, determine the potential energy savings and costs of implementing these measures and develop an implementation plan for those measures found to be most appropriate for the Regional Municipality of Hamilton-Wentworth.

The study was undertaken in two separate phases: in phase 1 a preliminary analysis was undertaken of approximately 21 transportation energy management measures as listed in Exhibit I. The evaluation of each of these measures involved a review of costs, potential energy savings, cost per litre of fuel saved, effect on accidents, impact on air quality, and interaction with other measures. Based on a review of each of these factors, a short list of potential measures was developed which were potentially the most cost-effective and which would provide the greatest overall energy savings for the Region. In phase 2, each of the measures recommended in the preliminary analysis was analyzed in greater detail. Where appropriate, the detailed analysis included items such as site specific surveys, interviews, and detailed analysis of local intersections, etc. As with the preliminary ana-

# EXHIBIT I

## LONG LIST OF MEASURES

### 1. TRAFFIC OPERATIONS

1.1 Alternative Signal Timing Plans for a Signal Network
1.2 Eliminating Localized Congestion Problems
1.3 Selected Removal of On-Street Parking
1.4 Signal Timing Flexibility Near Major Traffic Generators
1.5 Traffic Signal Flashing Operations
1.6 Alternative Traffic Control Measures at Local Intersections
1.7 Reversible Lanes in Corridors with High Directional Splits
1.8 Two-Way Left Turn Lanes

### 2. TRANSIT RELATED MEASURES

2.1 Exclusive or Shared Lanes for Buses and HOV's
2.2 Public Transit Level of Service and Pricing
2.3 More Frequent Bus Service During Rush Hours
2.4 Special Promotion of Off-Peak Bus Travel
2.5 Downtown Mini-Bus or Free Bus
2.6 Implementation of Express Bus Service on Selected Routes
2.7 Reduced Deadheading
2.8 Transit Vehicle Priority at Traffic Signals
2.9 Selected Installation of Bus Bays
2.10 Bus Stop Spacing and Location

### 3. LEGISLATIVE RELATED MEASURES

3.1 Control of Parking and Loading in Some Downtown Areas
3.2 Privately Operated Jitneys or Shared Taxis

### 4. HIGH OCCUPANCY VEHICLE (HOV) RELATED MEASURES

4.1 Preferential Treatment of HOV's
4.2 Additional Promotion of Carpool and Vanpool Programs
4.3 Fringe Parking Lots as Carpool and Vanpool Assembly Areas

### 5. OTHER MEASURES

5.1 Flexible and Staggered Hours, or Compressed Work Weeks
5.2 Improved Transportation Facilities
5.3 Educational Program to Encourage Grouping of Trips

lysis, the primary concern was the total potential energy savings, the cost of the measure, the cost per litre of fuel saved, and the impact on safety. Based on this analysis and the resulting evaluation, an implementation program was developed identifying the cost and staging for an energy management program for the Region.

As a point of explanation, the cost per litre of fuel saved reflects the cost of implementing an energy conservation measure and the associated energy savings in litres. Measures where the cost per litre of fuel saved is less than the cost to purchase a litre of fuel are considered cost effective.

## EXISTING TRANSPORTATION SERVICES, AND ENERGY CONSUMPTION IN THE REGION

A review was undertaken of the transportation system in the Region and an estimate was developed of the total base energy consumption for the study area. The major highlights of the review are:

- Hamilton Street Railway, which is the primary public transit service operator within the Region, accommodates approximately 85 annual rides per capita which is at, or above, the norm for a system of this size.

- The three road jurisdictions (Province, Region, local municipalities) are responsible for approximately 2,200 km of roads. The Province accounts for 10% of all the roads in the Region, the Region 24%, and the City of Hamilton 32%, and the other municipalities 34% .

- Based on the road section data and traffic volume data and speeds, annual energy consumption estimates were developed for the study area. The resulting estimate of approximately 715 million litres takes into account trucks and commercial vehicles, buses and cold starts.

- Because of the extensive one-way street system, especially in the downtown, and because of the actively managed and inter-connected traffic signal system, it was concluded that the potential energy savings, at least as they relate to traffic improvement measures, would not be as high as might be expected in other municipalities.

## PRELIMINARY EVALUATION

Exhibit II summarizes the analysis and findings for each of the measures analyzed in the preliminary evaluation. From this exhibit, nine measures were identified for more detailed analysis. The results are summarized below by each grouping.

### Traffic Operations Measures

Although the majority of traffic operations measures examined were potentially cost-effective in terms of energy savings, three were recommended for further analysis as listed below. Other cost effective traffic measures were not subjected to the detailed analysis because the preliminary analysis provided sufficient detail to confirm their energy efficiency (e.g. pedestrian actuated signals) or there was limited potential for large scale energy savings because of the limited number of possible applications (e.g. two-way left turns).

Measures recommended for further analysis:

- alternative signal timing plans for a signal network. The more detailed analysis made use of a traffic optimization program (TRANSYT) on a network of 34 signals;
- traffic signal flashing to assess, in addition to the energy savings, the safety and accident impacts;
- alternative traffic control measures at local intersections. Specifically, this included an analysis of converting stop sign control to yield, four way stops to signal control and replacing fixed time isolated signals with coordinated control or traffic responsive control. Accidents were of major concern with these measures.

The removal of on-street parking was not recommended because the energy cost effectiveness is dependent on the site characteristics. For example, if on-street parking spaces had to be replaced with parking in a structure, the cost per litre saved would be approximately $1.00. If the on-street spaces did not have to be replaced the cost per litre saved would be approximately $0.2.

# EXHIBIT II

## SUMMARY OF PRELIMINARY ANALYSIS

| MEASURE | SITE SPECIFIC ANALYSIS: ENERGY SAVINGS (INCREASE) L/YR. | REDUCTION IN CONSUMPTION (%) | ANNUAL COSTS | COST EFFECTIVENESS $/L | NO. OF POSSIBLE APPLICATIONS | POSSIBLE ANNUAL FUEL SAVINGS (1) | % RED. IN TOTAL FUEL CONSUMP. (AREA WIDE) | IMPACT ON AIR POLLUTION | EFFECT ON ACCIDENTS | INTERACTION WITH OTHER MEASURES | INSTITUTIONAL JURISDICTIONAL IMPLICATIONS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.0 TRAFFIC MEASURES | | | | | | | | | | | |
| 1.1 Alternative Signal Timing Plans | 6,670/signal | 2% | $70./signal | $.01 | 150 @ 2%<br>100 @ 1% | 1.33 million | .20% | decrease | decrease | negl. | none |
| 1.2 Eliminating Localized Congestion | | SEE NOTE 1 | | | | | | | | | |
| - excessive demand | 300 | 1% | $50/yr. | $.20 | - | - | - | - | - | negl. | none |
| - pedestrian timing | 12,000 | 23% (excess) | $650/yr. | $.05 | 10 | 120,000 | .02% | decrease | negl. | | none |
| 1.3 Removal of On-Street Parking | 2,300 | 3.5% | $45<br>$2,300 SEE NOTE 3 | $.02<br>$1.00 | 50 | 115,000 | .02% | decrease | decrease | none | local merchants |
| 1.4 Signal Timing Flexibility | 6,000 | 6.6% | $1,600 | $.27 | 16 | 96,000 | .01% | decrease | decrease | negative with signal co-ordination | none |
| 1.5 Traffic Signal Flashing | | | | | | | | | | | |
| - existing flash<br>- no flash | 200<br>750 | 0.6%<br>2.1% | $20<br>$35 | $.10<br>$.05 | 36<br>35 | 33,500 | .005% | decrease | increase | none | none |
| 1.6 Alternative Traffic Control | | | | | | | | | | | |
| - fixed time to coordination | 35,000 | 37% | $1,175 | $.03 | 30 | 1.07 million | .171% | decrease | none | none | none |
| - stops to yields | 4,500/intersection | 17.4% | $50 | $.01 | 900 | 4.05 million | .62% | decrease | significant increase | none | community reaction |
| - 4-way stops to signals | 47,300 | 39% | $3,200 | $.07 | 10 | 473,000 | .07% | decrease | increase | none | none |
| 1.7 Reversible Lanes | 10,000 | 3.2% | $8,000 | $.80 | 1 | 10,000 | .002% | negl. | potential increase | none | merchants |
| 1.8 Two-way Left Turn | 8,400 | 0.8% | $2,200 | | 2 | 16,800 | .003% | negl. | decrease | positive with interconnection | none |
| 2.0 TRANSIT MEASURES | | | | | | | | | | | |
| 2.1 Exclusive Lanes | 0 | 0 | - | - | 1 | - | - | - | potential increase | increased transit frequency | traffic negative impact |
| 2.2 Level of Service Improvements | 472,000 | - | $1.9 million | $2.30 | - | 472,000 | .07% | decrease | decrease | parking | HSR |
| 2.3 Increased Frequency (peak period) | (48,000) | increase | $449,000 | $8.33 SEE NOTE 2 | 20 | (960,000) | (.15%) | increase | increase | - | HSR |
| 2.4 Increased Promotion | | | | | area wide | | | possible reduction | | improved transit efficiency | HSR |
| 2.5 CBD Mini bus | increase | increase | | | | increase | increase | increase | none | none | HSR |

NOTE 1: Excess means consumption due to stops and delays
NOTE 2: Expenditure of 8.33 results in 1 litre increase in fuel consumption
NOTE 3: Range depends on how on-street spaces are replaced off-street (eg. parking structure)

EXHIBIT II
(Continued)

| MEASURE | SITE SPECIFIC ANALYSIS: ENERGY SAVINGS (L/Yr) | REDUCTION IN CONSUMPTION (%) | ANNUAL COSTS | COST EFFECTIVENESS ($/L) | NO. OF POSSIBLE APPLICATIONS | POSSIBLE ANNUAL FUEL SAVINGS (l) | % RED. IN TOTAL FUEL CONSUMP. (AREA WIDE) | IMPACT ON AIR POLLUTION | EFFECT ON ACCIDENTS | INTERACTION WITH OTHER MEASURES | INSTITUTIONAL JURISDICTIONAL IMPLICATIONS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2.6 Express Buses | 8,000 | - | (saves 1 bus) | - | 10 | 80,000 | .01% | decrease | decrease | parking CBD | HSR |
| 2.7 Reduced Dead Head During Start-up | 9,450 | - | $ 10,800 | $1.14 | 2 | 20,000 | negl. | negl. | negl. | none | HSR |
| 2.8 Signal Pre-emption | 450-900/ tr.sig. | - | $ 1,080 | $1.20 $2.40 | 100 | 45,000 - 90,000 | .01% | decrease | negl. | cross street traffic | traffic operations/HSR |
| 2.9 Selected Installation of Bus Bays | 190 | - | $ 1,760 | $9.26 | 50 | 9,500 | negl. | negl. | decrease | - | traffic operations HSR |
| 2.10 Bus Stop Spacing & Location | 648,000 | - | $ 16,500 | $ .03 | - | 648,000 | .1% | decrease | possible decrease | express buses | neg. public reaction |
| 3.0 LEGISLATIVE MEASURES | | | | | | | | | | | |
| 3.1 Controlled Parking and Loading in Downtown | 690,000 | - | $494,200 | $ .60 | - | 690,000 | .09% | decrease | decrease | poss. impact transit HOV's | public reaction |
| 3.2 Privately Operated Jitneys or Shared Ride Taxis | 350,000 | - | $50,000 | $ .14 | - | 350,000 | .05% | decrease | decrease | negl. | taxi by-laws taxi operators |
| 4.0 HOV RELATED MEASURES | | | | | | | | | | | |
| 4.1 Preferential Treatment HOV's | - | - | - | - | CBD/Major Emp. Centres | - | (4.2) | (4.2) | - | car and vanpool promotion | Major Employers Parking Auth. |
| 4.2 Car & Vanpool Promotion | 1.2 Million | - | $150,000 - $200,000 | $.12 - .17 | area wide | 1.2 million | .2% | decrease | decrease | parking inc. required | Prov./Region |
| 4.3 Fringe Parking | 350,000 | - | $ 35,000 - $ 47,000 | $.10 - .15 | 9 | 350,000 | .05% | decrease | decrease | Pos. on HOV's | Prov./Region |
| 5.0 OTHER MEASURES | | | | | | | | | | | |
| 5.1 Staggered, Flexible Hours and Compressed Work Week | | | | | | | | | | | |
| Staggered Flex | 74,000 | - | $25,000 | $.17 - $.50 | - | 74,000 | negl. | negl. | negl. | reduce transit peak | Region |
| Compressed | 1 million | - | $75,000 | $.02 - $.08 | - | 1 million | .15% | decrease | - | neg. on HOV | |
| 5.2 Improved Facilities for Low-Energy Vehicles | 216,000 | - | $60,000 | $.30 | - | 216,000 | .03% | decrease | possible increase | neg. effect on traffic | Region |
| 5.3 Education Program to Group Trips | 8.5 million | - | $850,000 | .10 | - | 8.5 million | 1.34% | decrease | decrease | - | Province |

Transit Measures

Only one transit measure was energy cost-effective in the short term: express buses. The detailed analysis of express buses focused on the potential costs of instituting such a service as well as the degree to which the measure would affect adjacent transit routes.

Legislative Measures

None of the legislative measures were recommended for further analysis. Legislative measures to restrict the supply of parking rates was evaluated and considered inappropriate because of the limited control the City and Region have over parking and the difficulty in instituting legislation to control private parking lots. Privately operated jitney service was not recommended because of the jurisdiction/institutional impediments (local municipal taxi by-laws).

High Occupancy Vehicle Measures

All three high occupancy vehicle measures were recommended for further consideration. Specifically, these included additional promotion of carpooling and vanpooling, preferential treatment of high occupancy vehicles (H O V.S ) at parking lots and fringe parking lots.

Other Measures

All of these measures were considered potentially cost-effective but only two were recommended for further analysis: staggered, flexible hours and compressed work week and improved facilities for low energy vehicles (bike-ways). An educational program to encourage grouping of trips was considered an appropriate measure to review with the Province.

DETAILED ANALYSIS

Each of the measures recommended for further analysis as a result of the preliminary assessment was subjected to a more thorough analysis and

evaluation. For example, two surveys were undertaken of the major employers in the Region to determine their willingness and interest in participating in various measures such as staggered flexible work hours, increased promotion of carpooling and vanpooling, etc. In addition, an extensive survey was undertaken of potential fringe parking locations along major commuter corridors both within and leading to the Region. In other cases, the detailed analysis involved analyzing the energy and other impacts of various measures at a number of different locations.

Exhibit III summarizes the results of the detailed analysis. If all the measures highlighted in the exhibit were implemented, the total energy saving would amount to approximately 12 million litres per year or 2% of the base energy consumption. However, not all measures are cost-effective as reflected by the cost per litre of fuel saved. For example, the estimated cost per litre of fuel saved when stop signs are replaced with yield signs ranges from 64¢ to $1.88 including accident costs.

## RECOMMENDATIONS

Based on the information summarized in Exhibit III, the following measures are recommended for inclusion as part of a transportation energy management program for the Region:

- Alternative Signal Timing Plans - this measure which applies to traffic signals provides the largest single possible energy saving - approximately 4 million litres per year. In addition, it is the single most cost-effective measure with the cost per litre of fuel saved being less than 1¢ per litre.

- Traffic Signal Coordination/Actuation - this measure would save an estimated 1 million litres of fuel per year at a cost per litre of between 1¢ and 2¢, if applied at appropriate locations. In the analysis of total energy savings, it was estimated that there are 30 locations where this measure might apply.

- Replacing Four-way Stops with Traffic Signals - this measure would result in approximately 300,000 litres of fuel saved annually at a cost of 12¢ per litre saved, if applied at selected locations. It is estimated that there are nine locations where the measure would apply.

# EXHIBIT III

## SUMMARY OF DETAILED ANALYSIS

| MEASURE | ENERGY SAVINGS TOTAL (litres/yr) | ENERGY SAVINGS % REDUCTION (area wide) | COST PER LITRE OF FUEL SAVED | SAFETY IMPACTS | INTERACTION WITH OTHER MEASURES |
|---|---|---|---|---|---|
| 1. Alternative Signal Timing Plans | 4,000,000 | 0.61 | $0.002 | Negligible | Negligible |
| 2. Traffic Signal Flashing | 155,000 | 0.02 | $.26 to $.39 (including accidents) | Significant Increase in Accidents | Negligible |
| 3. Signal Coordination/Actuation | 1,000,000 | 0.15 | $.014 Actuation<br>$.024 Coordination | - Minor Reduction in Collisions | Negligible Should be in conjunction with 1. |
| 4. Replace Stop Signs With Yield Signs | 3,800,000 | 0.58 | $.64 to $1.88 (including accidents) | Additional 440 Accidents/Year | Negligible |
| 5. Replace 4-Way Stops With Traffic Signals | 300,000 | 0.05 | $.12 | Negligible | Negligible |
| 6. Express Bus Service | 180,000 | 0.02 | $0.37 | Negligible | Negligible |
| 7. Additional Promotion of Carpooling and Vanpooling | Phase 1<br>777,200<br>Phase 2<br>1,120,000 | 0.12<br><br>0.17 | $0.28<br><br>$0.24 | Negligible | Fringe Parking Flexible, Staggered Hours |
| 8. Fringe Parking Lots | 321,000 | 0.05 | $0.19<br>$0.23 | Negligible | Carpooling and Vanpooling |
| 9. Flexible, Staggered Hours or Compressed Work Week | 400,000<br>800,000 | 0.06<br>0.12 | $0.20<br>$0.10 | Negligible | Carpooling and Vanpooling |
| 10. Improved Facilities for Low Energy Vehicles | 54,000 | 0.01 | $1.10 | Possible Increase | Negligible |

- Express Bus Service - although the express bus service would not result in large energy savings as compared to other measures, it would provide other benefits and the cost per litre of fuel saved is reasonable, if applied on selected routes.

- Additional Promotion of Car and Vanpooling - this measure is recommended because of the potential energy savings which range from approximately 700,000 litres per year through to approximately 1.1 million litres per year. Moreover, the cost per litre of fuel saved is in the range of 24¢ to 28¢ and there are significant other benefits such as reduced air pollution and travel costs.

- Fringe Parking Lots - this measure would result in an estimated 320,000 litres of fuel saved per year at a cost per litre saved of between 19¢ and 23¢. These lots are best suited to the major transportation corridors.

- Flexible, Staggered Hours or Compressed Work Week - this measure has potential to save between 400,000 and 800,000 litres of fuel per year at a cost per litre saved of between 10¢ and 20¢.

Two other measures that are recommended but which were not considered in the detailed evaluation are pedestrian actuated signals and a promotional program to encourage the grouping of trips.

From the preliminary analysis it was indicated that the pedestrian actuated signals would save approximately 12,000 litres per year per location at a cost of 5¢ per litre saved. Although the 10 potential sites where the measure might be applied does not result in large energy savings it is a measure that could be implemented inexpensively as part of a regular traffic engineering program.

As for an educational program to encourage the grouping of trips, (i.e. the combining of trips such as a shopping trip with a work trip) the measure offers significant potential but requires more research. In this regard, it might be appropriate for the Region to approach the Province and have them consider a research project in this area.

## IMPLEMENTATION PROGRAM

Exhibit IV summarizes the estimated timing, start-up and capital costs and any on-going costs for the recommended measures.

The capital or start-up costs for all the recommended measures is estimated at between $880,000 to $1,055,000 with ongoing annual operating costs of approximately $320,000. The annual costs are relatively small because many of the measures don't require ongoing costs. The largest annual cost is for the promotion of carpooling and vanpooling which could be combined with the promotion of flexible, staggered hours or compressed work week because of the similar types of activities (e.g. marketing service to employees and employers).

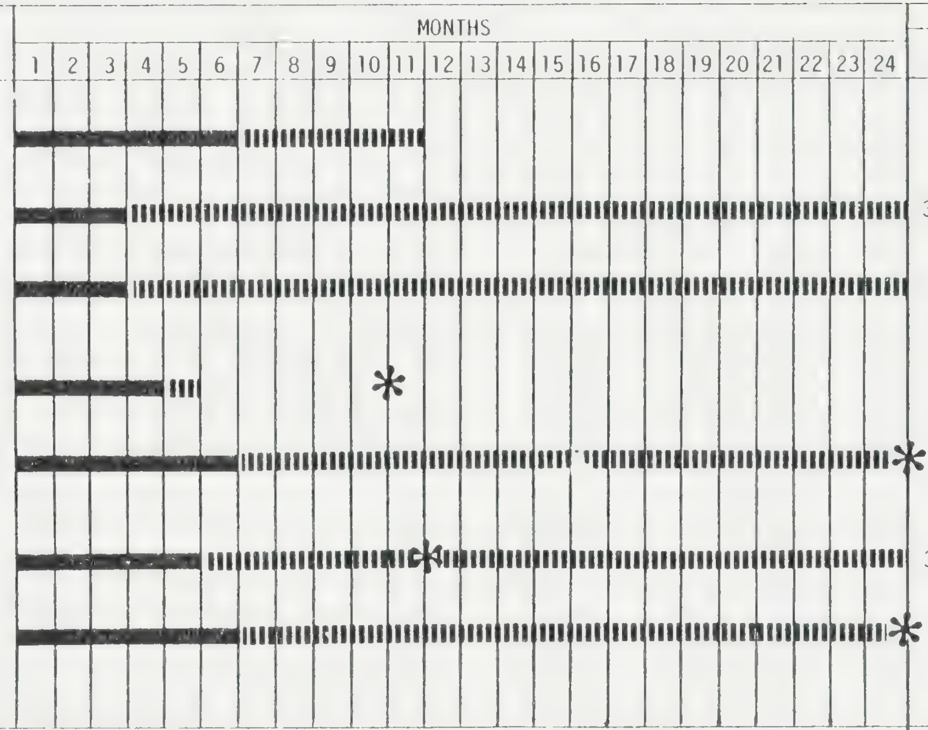
The estimated annual fuel savings of 6.98 million litres, although only 1% of the base energy consumption are significant. What is more significant is that the cost per litre of fuel saved ranges from $0.002 to $0.37 with a weighted (on the basis of fuel savings) cost per litre of fuel saved of less than 6¢ per litre.

All of the traffic operations measures as well as the express bus measure could be implemented by the Region directly and should be eligible under existing Provincial cost sharing arrangements for traffic signal timing improvements, transit service subsidies, etc. Three measures, the additional promotion of carpooling and vanpooling, fringe parking lots and flexible, staggered hours or compressed work week are relatively new concepts which have not been applied in a comprehensive fashion in other Canadian cities - they have been very successful in a number of U.S. cities. For this reason, it would be appropriate for the Region to approach the MTC to consider a shared program of implementation.

In summary, transportation management measures can result in significant and cost-effective energy savings. Thus, comprehensive urban transportation energy management program can play an important role in reducing our reliance on expensive and unreliable foreign energy supplies.

# EXHIBIT IV

## IMPLEMENTATION SCHEDULE




| TRANSPORTATION MEASURE | COSTS: CAPITAL START-UP | COSTS: OPERATING (ANNUAL) | FUEL SAVINGS (LITRES) | COST PER LITRE SAVED |
|---|---|---|---|---|
| Alternative Signal Timing Plans | 30,000 | -(1) | 4,000,000 | $0.002 |
| Signal Coordination/Actuation | 300,000-400,000 | -(1) | 1,000,000 | $.01 to $.02 |
| Replace Four-Way Stop Signs With Signals | 200,000 | -(1) | 300,000 | $.12 |
| Express Bus Service | 15,000 | -(2) | 180,000 | $.37 |
| Additional Promotion of Carpooling and Vanpooling | 35,000 | 215,000 | 777,000 to 1,100,000 | $.24 to $.28 |
| Fringe Parking Lots | 300,000-375,000 | 25,000 | 321,000 | $.17 to $.23 |
| Flexible, Staggered Hours or Compressed Work Week | - | 80,000(3) | 400,000 to 800,000 | $.10 to $.20 |
| TOTAL | $880,000 - $1,055,000 | $320,000 | $6.98 - $7.7 Mil. | $0.002 to $.37 |

LEGEND:

- Initial Planning
- Implementation
- * Monitoring/Evaluation

NOTES:

1. No on-going operating costs.
2. Assumed as part of regular HSR operating budget.
3. If combined with promotion of carpooling and vanpooling this cost could be reduced significantly.

# 1 - INTRODUCTION

The growing world-wide concern about the increasing scarcity and cost of energy focusses particularly on petroleum. Oil and its derivatives have been a dominant form of energy for the past 50 years, particularly for applications requiring portability, ease of handling and high energy content per unit volume. Transportation is such an application, and it is therefore not surprising that 49 percent of petroleum fuels consumed in Ontario are used in the transportation sector. While petroleum fuels are used by the marine, air and rail modes, road transportation is the major user, consuming some 83 percent of transportation fuels used in Ontario, or 41 percent of total Ontario petroleum consumption. Of the petroleum fuel used in the road transport sector, private automobiles are the dominant users accounting for some 56 percent of consumption.

Clearly, urban automotive traffic, and particularly private automobiles, are a prime target for efforts to conserve petroleum. These efforts can include conservation and the use of alternative fuels. This study deals primarily with conservation measures, with particular emphasis on more efficient traffic operations, incentives to increase vehicle occupancy and greater use of transit, and incentives to reduce or smooth travel demand.

## 1.1 STUDY PURPOSE

The primary objective of this study is to develop a transportation energy management plan for the Regional Municipality of Hamilton-Wentworth.

The Province has adopted transportation objectives for energy conservation which provide a broad perspective to this study. These objectives are:

- for passenger transportation, to reduce the fuel consumed per person kilometre by 33% between 1980 and 1995;
- for freight transportation, to reduce the fuel consumed per tonne kilometre by 20% between 1980 and 1995.

## EXHIBIT 1.1

## LONG LIST OF MEASURES

### 1. TRAFFIC OPERATIONS

1.1 Alternative Signal Timing Plans for a Signal Network
1.2 Eliminating Localized Congestion Problems
1.3 Selected Removal of On-Street Parking
1.4 Signal Timing Flexibility Near Major Traffic Generators
1.5 Traffic Signal Flashing Operations
1.6 Alternative Traffic Control Measures at Local Intersections
1.7 Reversible Lanes in Corridors with High Directional Splits
1.8 Two-Way Left Turn Lanes

### 2. TRANSIT RELATED MEASURES

2.1 Exclusive or Shared Lanes for Buses and HOV's
2.2 Public Transit Level of Service and Pricing
2.3 More Frequent Bus Service During Rush Hours
2.4 Special Promotion of Off-Peak Bus Travel
2.5 Downtown Mini-Bus or Free Bus
2.6 Implementation of Express Bus Service on Selected Routes
2.7 Reduced Deadheading
2.8 Transit Vehicle Priority at Traffic Signals
2.9 Selected Installation of Bus Bays
2.10 Bus Stop Spacing and Location

### 3. LEGISLATIVE RELATED MEASURES

3.1 Control of Parking and Loading in Some Downtown Areas
3.2 Privately Operated Jitneys or Shared Taxis

### 4. HIGH OCCUPANCY VEHICLE (HOV) RELATED MEASURES

4.1 Preferential Treatment of HOV's
4.2 Additional Promotion of Carpool and Vanpool Programs
4.3 Fringe Parking Lots as Carpool and Vanpool Assembly Areas

### 5. OTHER MEASURES

5.1 Flexible and Staggered Hours, or Compressed Work Weeks
5.2 Improved Transportation Facilities
5.3 Educational Program to Encourage Grouping of Trips

The Provincial Transportation Energy Management Program (TEMP) target for energy conservation in the transportation sector is a 10% savings by 1985 over and above U.S. legislated automobile performance standards.

## 1.2 STUDY APPROACH

The Transportation Energy Management measures considered in the study are listed in Exhibit 1.1. As indicated, these are grouped under five headings:

- traffic operations (eight measures)
- transit related measures (ten measures)
- legislative measures (two measures)
- high occupancy vehicle (HOV) related measures (three measures)
- other measures (three measures)

In total, some 26 Traffic Energy Management measures were considered.

A two step process was applied in evaluating these measures. The first step was a preliminary evaluation based on published documentation. The second step was a detailed analysis of the highest priority measures identified in the preliminary evaluation. The detailed evaluation formed the basis for the implementation program.

In the study, each of the measures was evaluated with respect to energy saving, cost effectiveness (i.e. cost per litre of fuel saved), accidents, person delay, and emissions. It is important to point out that, some measures which are now standard engineering practice for safety or other reasons would not necessarily rank high in terms of energy savings.

## 2 - REVIEW OF TRANSPORTATION SERVICES, DEMAND AND ENERGY CONSUMPTION

The Hamilton-Wentworth Region consists of six municipalities: Hamilton, Ancaster, Dundas, Stoney Creek, Flamborough and Glanbrook. The 1980 assessed population for this study area was approximately 410,000 people with an average annual growth rate over the previous seven years of less than 0.5%. The estimated total employment within the study area is approximately 166,000 ranging from some agricultural employment in the outlying areas of the Region to heavy industrial employment in the Bayfront area. The major concentration of employment is to the north of the Niagara escarpment which in 1971 accounted for approximately 115,000 employees.

Of the 410,000 people within the study area, 75% are located within the boundaries of the city of Hamilton. Approximately 40% of the population within the Region is south of the Niagara escarpment which, taking into account the concentration of basic employment located north of the escarpment, results in concentrated demand along the limited access points linking the north and south sides of the escarpment.

### 2.1 TRANSPORTATION SUPPLY

The major elements of the transportation supply system in Hamilton/Wentworth include Hamilton Street Railway (HSR) and the road system.

#### 2.1.1 Hamilton Street Railways

Hamilton Street Railways is the primary transit operator within the Region. HSR operates 33 transit routes with a service population of approximately 325,000 people, and approximately 14 million kilometres of service and 28,000,000 revenue passengers annually. The service covers the major urbanized areas within the Region. The large majority of the routes have a terminus in the central business district.

The transit service accommodates approximately 85 annual rides per capita which is at, or above, the norm for a system of this size.

### 2.1.2 Road Network

The road network within the region comes under three jurisdictions: the Province, the Region and local municipalities. The Province is responsible for all provincial highways which include the Q.E.W. and Highway 403, and a small portion of Highway 8. The Region has jurisdiction over approximately 540 kilometres of regional roads which are defined as roads that connect urban centres, provincial highways and special land use areas.

There are approximately 1500 kilometres of municipal or lower tier roads that are under the jurisdiction of local municipalities. These roads are generally local streets or collectors. The City of Hamilton accounts for the largest share of lower tier roads; over 720 kilometres.

Within the city of Hamilton, there is an extensive network of one way streets which provides for smooth flow of traffic even during peak periods; typical p.m. peak hour speeds are in the range of 30-40 kilometres per hour. The major reason for these higher speeds, in addition to the one-way street network is the traffic signal system. Of the approximately 293 signals under regional jurisdiction, 253 are interconnected as part of four separate systems the largest of which includes 192 signals. The majority of the signals operate under a three dial system with specified signal offsets. Furthermore, there is an active signal timing improvement program to ensure proper signal timings.

## 2.2 TRAVEL DEMAND CHARACTERISTICS

In reviewing the travel characteristics within Hamilton-Wentworth two main sources of information were employed: the "Travel Characteristics Survey" conducted by the Regional Planning and Development Department in October 1975 and "1979 Travel to Work Survey" conducted by Statistics Canada.

Exhibit 2.1 summarizes some of the major findings of the Travel Characteristics Survey. Many of these findings were employed in examining specific transportation energy management measures. Some of the findings are, however, of general importance as background. These include:

EXHIBIT 2.1

TRAVEL SURVEY SUMMARY

| | | | |
|---|---|---|---|
| Persons/Household | 2.95 | | |
| Autos/Household | 1.20 | | |
| Person Trips/Household | 6.254 | | |
| Vehicle Driver Trips/Household | 3.61 | | |
| Labour Participation Rate | .40 | | |
| Average Trip Length Work (min.) | 15.5 | | |
| Average Trip Length Other (min.) | 11.4 | | |
| Mode of Travel | 24 hr | | P.M. Peak |
| Auto Driver | 59.6 | | 65.0% |
| Auto Passenger | 20.3 | | 17.8% |
| Transit | 11.7 | | 11.9% |
| Other | 8.4 | | 5.3% |
| Transit Captives | 87.9% | | |
| Trip Generation Rates (24hr) | | | |
| Home-based Work | | 2.024 | |
| Home-based Shopping & Personal Business | | 1.223 | |
| Home-based Social, Recreational & Other | | .873 | |
| Home-based School | | .619 | |
| | 24 hr | | P.M. Peak |
| Estimated Transit Mode Split CBD | 21% | | 27% |

Source: Travel Characteristics Survey
The Regional Municipality of Hamilton-Wentworth
Planning and Development Department (Oct. 1975)

- the transit mode split of 11-12% does not vary appreciably between the p.m. peak and the average for 24 hours. These mode splits are based on home based trips with destinations throughout the region. Of particular importance is the mode split to the central business district which is estimated to be 21% for 24 hours or 27% for the p.m. peak hour;

- the auto occupancy rate is approximately 1.35 for a 24 hour period but decreases to approximately 1.27 during the p.m. peak period, this would suggest that the auto occupancy rates are lower for work trips than for other trips;

- the large majority of transit users are captive, approximately 88%;

- the home based work trip accounts for approximately 32% of all home based travel during a typical week day.

Exhibit 2.2 summarizes some of the more important elements of the 1979 Travel to Work Survey for the Hamilton Census Metropolitan Area (CMA). Although the CMA boundaries do not coincide exactly with the regional municipality they do provide a reasonable basis for comparison. From the Exhibit, it is evident that the auto mode of travel accounts for the largest proportion of work trip travel (approximately 79%) and transit accounts for approximately 14%. The walk mode is also critical in Hamilton, accounting for approximately 7% of all work trip travel. As was suggested in the findings from the travel summary conducted by the Regional Planning Department, the work trip auto occupancy rate is lower than that of other home base trips. Moreover, over 75% of all employees travel to work alone. Another important finding of the 1979 Travel to Work Survey is the cost of parking. Approximately 95% of all employees in the census Metropolitan Area have free parking.

## 2.3 ESTIMATES OF ENERGY CONSUMPTION

One of the important aspects of a transportation energy management study is assessing the energy impacts of particular measures on the total transportation energy consumption. One of the difficulties in assessing such is deriving an energy consumption base. Although there are a number of techniques to estimate energy consumption, the method applied was based on street

## EXHIBIT 2.2

## 1979 TRAVEL TO WORK SUMMARY HAMILTON CENSUS METROPOLITAN AREA (CMA)

| | |
|---|---|
| **Mode** | |
| Auto | 78.4% |
| Bus | 13.9% |
| Walk | 7.0% |
| Other | .7% |
| | 100.0% |
| **Status of Auto User** | |
| Drove alone | 76.4% |
| Drove with passenger | 7.6% |
| Shared driving | 1.8% |
| Rode as Passenger | 14.2% |
| | 100.0% |
| Average Auto Accupancy 1.19 | |
| **Cost of Parking** | |
| Free | 95.2% |
| $1.00/day | 2.5% |
| 2.00/day | 1.6% |
| 3.00/day | .8% |
| 4.00/day | —— |
| | 100.0% |

Source: Statistics Canada , 1979 Travel to Work Survey

section characteristics. This technique was considered most appropriate because it provides a distribution of fuel consumption by jurisdiction.

The energy estimate was developed using an equation shown in Exhibit 2.3 which relates the length of road section, the average travel time and the number of vehicles to provide estimates of energy consumption. In applying this equation to the provincial, regional and municipal roads in the study area, assumptions had to be made of certain variables (eg. speeds and volumes). Appendix A summarizes the relevant assumptions.

Using the equation, the base energy consumption for the study area was estimated to be approximately 715 million litres per year taking into account trucks, buses and cold starts. Because each of the measures evaluated did not specifically address cold starts the base consumption for comparison purposes was approximately 650 million litres/year.

One of the difficulties with a multifaceted transportation energy management program is that it is extremely difficult to determine actual consumption characteristics and therefore monitor the impact of any specific energy conservation program other than through fuel sales. But fuel sales reflect various other factors, the most notable being the fuel efficiency standards and is thus an imperfect indicator.

* * * * * *

Because of the transit market penetration by HSR as reflected by annual rides per capita, the extensive network of one-way streets and interconnected signals, and the active traffic signal timing program, the potential energy savings in Hamilton Wentworth through Transportation Energy Management Measures is probably less than that which might be achieved in most other municipalities.

## EXHIBIT 2.3

## FUEL CONSUMPTION ESTIMATING EQUATION

$$\text{Fuel Consumed (litres/year)} = \sum_{i=1}^{n} (100.4 \cdot D_i + 0.63 \cdot T_i) \cdot N_i \cdot C_1 \cdot C_2 \cdot C_3 \cdot C_4$$

where:

$D_i$ = the total distance of each road type i in km

$T_i$ = the travel time in secs (i.e. the reciprocal of the average speed on road type i multiplied by $D_i$)

$N_i$ = the average annual daily traffic for each road type i

$C_1$ = 365.25 (a factor to allow for the upgrading of AADT to yearly traffic)

$C_2$ = 1.220 (a factor applied to allow for increased fuel consumption rates due to cold starts)

$C_3$ = 0.9635 (a factor applied to allow for the improved fuel efficiency resulting from the automobile fleet change since 1979)

$C_4$ = 0.001 a constant of the equation

i = the various road classifications for each jurisdiction
e.g. Regional Roads (width and surface type)
Municipal Roads (urban/semi-urban/rural by arterial/collector/local)

Source: Based on equation in "Traffic Management Measures to Reduce Energy Consumption" prepared by IBI Group for TEMP, Nov. 1981.

# 3 - DESCRIPTION AND PRELIMINARY EVALUATION OF TRANSPORTATION ENERGY MANAGEMENT MEASURES

This chapter summarizes the results of the preliminary evaluation. The purpose of the preliminary evaluation was to identify those measures which would provide potentially cost-effective energy savings. The energy and other impacts were assessed based on published reports, papers etc. The preferred measures identified in the preliminary analysis were subjected to a more detailed analysis which is described in Chapter 4.

## 3.1 DESCRIPTION OF MEASURES

Exhibit 3.1 summarizes the 26 transportation energy management measures that were analyzed, provides a brief description of these measures, and, where appropriate, identifies the locations and times for which the analysis was undertaken. In certain traffic operation measures two or three sub-measures were also examined. For example, signal timing improvements and pedestrian actuation of traffic signals were assessed as part of 1.2, Eliminating Localized Congestion. For measure 1.6, Alternative Traffic Control Measures at Local Intersections, three sub-measures were analyzed: signal co-ordination versus actuation, replacing stop signs with yield signs and replacing four way stop signs with traffic signals.

As is evident in reviewing Exhibit 3.1 the 26 measures reviewed included supply improvements to the transportation system such as improved traffic operations; incentive measures to alter travel demand characteristics such as improved public transit and increased promotion of carpools and vanpools; disincentives such as higher parking rates; and public education and information such as the encouragement of grouping trips. With this range of measures it is possible to develop a comprehensive program which takes into account the complementary and supportive nature of the various measures such that two or three measures implemented in a coordinated fashion can achieve benefits that exceed those of implementing measures independently.

# EXHIBIT 3.1

## DESCRIPTION OF TRANSPORTATION ENERGY MANAGEMENT MEASURES ASSESSED DURING PRELIMINARY EVALUATION

### 1.0 Traffic Operations Measures

#### 1.1 Alternative Signal Timing Plans For a Network

- manually assessed the offsets at 9 intersections along Mohawk Road from West 5th to Wentworth and Upper James Street from Hester St. to Brantdale Avenue for the p.m. peak period.

#### 1.2 Eliminating Localized Congestion Problems

- developed alternative signal timing at Queenston Road and Centennial Parkway for the p.m. peak hour.

- implementing pedestrian actuated walk phase at York Boulevard and Dundurn Street

#### 1.3 Selected Removal of On-Street Parking

- assessed the removal of on-street parking on Barton Street between Kenilworth and Strathearn Avenues.

#### 1.4 Signal Timing Flexibility

- examined alternative signal timing plans during 2 selected hours of Saturday operation at the intersection of Queenston Road and Centennial Parkway.

#### 1.5 Traffic Signal Flashing Operations

- evaluated the effects night flash operation at the intersection of Birch Avenue and Brant Street for a typical weekday operation.

#### 1.6 Alternative Traffic Control Measures at Local Intersections

- examined signal coordination versus actuation for the intersections of Barton Street and Green Road and Barton Street and Millen Road.

- examined replacing stop signs with yield signs at three intersections in Crown Point East.

- assessed replacing 4-way stop signs with traffic signals.

#### 1.7 Reversible Lanes in Corridors with High Directional Split

- examined reversible lanes for Main St. West from Cootes Dr. to Osler Dr.

#### 1.8 Two-Way Left Turn Lanes

- assessed two-way left turn lanes for Main St. West from Cootes Dr. to Osler Dr.

### 2.0 Transit Related Measures

#### 2.1 Exclusive Lanes for Buses

- examined an exclusive bus lane on Concession St. from the top of the Jolley Cut to Henderson Hospital.

#### 2.2 Public Transit Level of Service

- examined the impacts of a 10% increase in the vehicle kilometres of transit service throughout Hamilton.

#### 2.3 More Frequent Bus Service During Rush Hours

- examined increase transit service during rush hours on route 4 and route 5.

#### 2.4 Special Promotion of Off-Peak Bus Travel

- reviewed available literature on increased promotion of transit service.

EXHIBIT 3.1
(Continued)

2.5 Downtown Mini Bus

- briefly assessed the impact of a downtown mini bus.

2.6 Implementation of Express Bus Service on a Selected Route

- examined the impacts of implementing an express bus service between the University and the downtown.

2.7 Reduced Deadheading

- examined the impacts of a remote operating station to store transit vehicles providing service to Stoney Creek.

2.8 Transit Vehicle Priority at Traffic Signals

- reviewed the literature on signal pre-emption and assessed the general impacts in Hamilton.

2.9 Selected Installation of Bus Bays

- assessed the energy impacts of a bus bay at the intersection of Upper James and Mohawk during the p.m. peak hour.

2.10 Bus Stop Spacing and Locations

- reviewed HSR bus stop spacing policy and assessed impacts of longer spacings.

3.0 Legislative Related Measures

3.1 Control of Parking and Loading in Downtown Areas

- examined the impacts of higher long term parking rates in the downtown.

3.2 Privately Operated Jitneys

- reviewed the impacts of shared ride taxi operations.

4.0 High Occupancy Vehicle (HOV) Related Measures

4.1 Preferential Treatment of HOV'S

- generally reviewed the importance of preferential parking rates and locations for HOV's.

4.2 Additional Promotion of Car and Vanpools

- reviewed the area wide impacts of comprehensive ride-sharing program for the Hamilton area.

4.3 Fringe Parking Lots as Carpool and Vanpool Assembly Areas

- examined the impacts of installing fringe parking lots near the major highways into Hamilton.

5.0 Other Measures

5.1 Flexible, Staggered Hours or Compressed Work Weeks

- examined the impacts of flexible, staggered hours in the downtown and a compressed work week at major employment centres.

5.2 Improved Transportation Facilities

- generally assessed the impacts for bikeways in Hamilton.

5.3 Educational Program to Encourage Grouping of Trips

- assessed the potential of grouping of trips to reduce energy consumption.

## 3.2 EVALUATION PROCEDURES

### 3.2.1 Evaluation Criteria

The primary criteria used in evaluating the described measures include:

- cost-effectiveness: this criterion deals with the costs associated with each litre of fuel saved. The costs include capital costs which were annualized based on a 5% discount rate reflecting real interest costs and the appropriate life cycles, as well as annual operating costs. The annual energy savings were estimated from the actual assessment of impacts for the particular measure;

- total potential energy savings: for this criterion the energy savings as derived for a specific application of a particular measure were, as appropriate, factored to an area wide saving based upon the number of potential sites at which the measure could be applied (eg. there are a total of 10 potential locations for pedestrian actuated signal equipment);

- air pollution: this criterion was assessed in a qualitative/subjective measure. However, air pollution impacts are usually proportional to the energy impacts;

- effects on accidents: this measure was also assessed qualitatively based on, where appropriate, available published documentation or judgement;

- interaction with other measures: in some cases the interaction of a measure with various other measures or other modes of travel was included as part of the analysis (eg. increased parking rates in the downtown would have an impact on transit, ride-sharing, etc.);

- institutional/jurisdictional implications: this criterion generally refers to the ease by which a particular measure can be implemented. In some cases, measures can be implemented quickly, with minimal institutional/jurisdictional problems because the responsibility for implementing the measure would reside with one jurisdiction (eg. improved traffic signal timings). However, in situations where there is a significant degree of interaction between measures and there is more than one jurisdiction involved, implementation can be difficult because of the required cooperation between the respective agencies. In certain cases, the responsibility for implementing measures may lie with agencies external to the region.

In many cases, other criteria such as changes in travel speeds or travel time, mode splits, net change in person travel, etc., were assessed as part of the quantitative analysis of estimating the cost-effectiveness.

### 3.2.2 Evaluation Approach

In evaluating a number of the measures, the approach was to identify, where appropriate, specific locations for which the measure might reasonably apply. For each of the locations which were identified a detailed assessment of impacts focusing on energy savings and costs was undertaken. From this analysis, the cost-effectiveness of a particular measure was estimated. Once the energy savings were identified for a specific location, the potential area wide savings were estimated based on the additional locations where a measure might be applied. Assistance in identifying these additional locations was provided by City and Regional staff. Thus the degree to which a particular measure truly reflects the area wide potential is based on the assumption that the site examined reasonably represents an average operating condition.

## 3.3 RESULTS OF PRELIMINARY ANALYSIS

Exhibit 3.2 summarizes the major results of the preliminary analysis for the identified measures with particular emphasis on the quantitative criteria such as energy savings, costs, number of application area wide and possible annual fuel savings area wide. The table also summarizes qualitative assessments such as impact on air pollution, effects on accidents, interaction with other measures and institutional/jurisdictional implications.

As is evident from the Exhibit, the total potential energy savings for all the measures considered is approximately 3% of base fuel consumption or 19.4 million litres of fuel per year. This is generally lower than generalized estimates that have been developed and published. The reasons for this include:

# EXHIBIT 3.2

## SUMMARY OF PRELIMINARY ANALYSIS

| MEASURE | SITE SPECIFIC ANALYSIS: ENERGY SAVINGS (INCREASE) L/YR. | SITE SPECIFIC ANALYSIS: REDUCTION IN CONSUMPTION (%) | SITE SPECIFIC ANALYSIS: ANNUAL COSTS | SITE SPECIFIC ANALYSIS: COST EFFECTIVENESS $/L | NO. OF POSSIBLE APPLICATIONS | POSSIBLE ANNUAL FUEL SAVINGS (l) | % RED. IN TOTAL FUEL CONSUMP. (AREA WIDE) | IMPACT ON AIR POLLUTION | EFFECT ON ACCIDENTS | INTERACTION WITH OTHER MEASURES | INSTITUTIONAL JURISDICTIONAL IMPLICATIONS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.0 TRAFFIC MEASURES | | | | | | | | | | | |
| 1.1 Alternative Signal Timing Plans | 6,670/signal | 2% | $70./signal | $.01 | 150 @ 2%<br>100 @ 1% | 1.33 million | .20% | decrease | decrease | negl. | none |
| 1.2 Eliminating Localized Congestion | | SEE NOTE 1 | | | | | | | | | |
| - excessive demand | 300 | 1% | $50/yr. | $.20 | - | - | - | - | - | negl. | none |
| - pedestrian timing | 12,000 | 23% (excess) | $650/yr. | $.05 | 10 | 120,000 | .02% | decrease | negl. | | none |
| 1.3 Removal of On-Street Parking | 2,300 | 3.5% | $45<br>$2,300 SEE NOTE 3 | $.02<br>$1.00 | 50 | 115,000 | .02% | decrease | decrease | none | local merchants |
| 1.4 Signal Timing Flexibility | 6,000 | 6.6% | $1,600 | $.27 | 16 | 96,000 | .01% | decrease | decrease | negative with signal co-ordination | none |
| 1.5 Traffic Signal Flashing | | | | | | | | | | | |
| - existing flash<br>- no flash | 200<br>750 | 0.6%<br>2.1% | $20<br>$35 | $.10<br>$.05 | 36<br>35 | 33,500 | .005% | decrease | increase | none | none |
| 1.6 Alternative Traffic Control | | | | | | | | | | | |
| - fixed time to coordination | 35,000 | 37% | $1,175 | $.03 | 30 | 1.07 million | .171% | decrease | none | none | none |
| - stops to yields | 4,500/intersection | 17.4% | $50 | $.01 | 900 | 4.05 million | .62% | decrease | significant increase | none | community reaction |
| - 4-way stops to signals | 47,300 | 39% | $3,200 | $.07 | 10 | 473,000 | .07% | decrease | increase | none | none |
| 1.7 Reversible Lanes | 10,000 | 3.2% | $8,000 | $.80 | 1 | 10,000 | .002% | negl. | potential increase | none | merchants |
| 1.8 Two-way Left Turn | 8,400 | 0.8% | $2,200 | | 2 | 16,800 | .003% | negl. | decrease | positive with interconnection | none |
| 2.0 TRANSIT MEASURES | | | | | | | | | | | |
| 2.1 Exclusive lanes | 0 | 0 | - | - | 1 | - | - | - | potential increase | increased transit frequency | traffic negative impact |
| 2.2 Level of Service Improvements | 472,000 | - | $1.9 million | $2.30 | - | 472,000 | .07% | decrease | decrease | parking | HSR |
| 2.3 Increased Frequency (peak period) | (48,000) | increase | $449,000 | $8.33 SEE NOTE 2 | 20 | (960,000) | (.15%) | increase | increase | - | HSR |
| 2.4 Increased Promotion | | | | | area wide | | | possible reduction | | improved transit efficiency | HSR |
| 2.5 CBD Mini-bus | increase | increase | | | | increase | increase | increase | none | none | HSR |

NOTE 1: Excess means consumption due to stops and delays
NOTE 2: Expenditure of 8.33 results in 1 litre increase in fuel consumption
NOTE 3: Range depends on how on-street spaces are replaced off-street (eg. parking structure)

EXHIBIT 3.2
(Continued)

| MEASURE | SITE SPECIFIC ANALYSIS: ENERGY SAVINGS (L/Yr) | REDUCTION IN CONSUMPTION (%) | ANNUAL COSTS | COST EFFECTIVENESS ($/L) | NO. OF POSSIBLE APPLICATIONS | POSSIBLE ANNUAL FUEL SAVINGS (l) | % RED. IN TOTAL FUEL CONSUMP. AREA WIDE | IMPACT ON AIR POLLUTION | EFFECT ON ACCIDENTS | INTERACTION WITH OTHER MEASURES | INSTITUTIONAL JURISDICTIONAL IMPLICATIONS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2.6 Express Buses | 8,000 | - | (saves 1 bus) | - | 10 | 80,000 | .01% | decrease | decrease | parking CBD | HSR |
| 2.7 Reduced Dead Head During Start-up | 9,450 | - | $ 10,800 | $1.14 | 2 | 20,000 | negl. | negl. | negl. | none | HSR |
| 2.8 Signal Pre-emption | 450-900/ tr.sig. | - | $ 1,080 | $1.20 $2.40 | 100 | 45,000 - 90,000 | .01% | decrease | negl. | cross street traffic | traffic operations/HSR |
| 2.9 Selected Installation of Bus Bays | 190 | - | $ 1,760 | $9.26 | 50 | 9,500 | negl. | negl. | decrease | - | traffic operations HSR |
| 2.10 Bus Stop Spacing & Location | 648,000 | - | $ 16,500 | $ .03 | - | 648,000 | .1% | decrease | possible decrease | express buses | neg. public reaction |
| 3.0 LEGISLATIVE MEASURES | | | | | | | | | | | |
| 3.1 Controlled Parking and Loading in Downtown | 690,000 | - | $414,200 | $ .60 | - | 690,000 | .09% | decrease | decrease | poss. impact transit HOV's | public reaction |
| 3.2 Privately Operated Jitneys or Shared Ride Taxis | 350,000 | - | $50,000 | $ .14 | - | 350,000 | .05% | decrease | decrease | negl. | taxi by-laws taxi operators |
| 4.0 HOV RELATED MEASURES | | | | | | | | | | | |
| 4.1 Preferential Treatment HOV's | - | - | - | - | CBD/Major Emp. Centres | - | (4.2) | (4.2) | - | car and vanpool promotion | Major Employers Parking Auth. |
| 4.2 Car & Vanpool Promotion | 1.2 Million | - | $150,000 - $200,000 | $.12 - .17 | area wide | 1.2 million | .2% | decrease | decrease | parking inc. required | Prov./Region |
| 4.3 Fringe Parking | 350,000 | - | $ 35,000 - $ 47,000 | $.10 - .15 | 9 | 350,000 | .05% | decrease | decrease | Pos. on HOV's | Prov./Region |
| 5.0 OTHER MEASURES | | | | | | | | | | | |
| 5.1 Staggered, Flexible Hours and Compressed Work Week | | | | | | | | | | | |
| Staggered Flex | 74,000 | - | $25,000 | $.17 - $.50 | - | 74,000 | negl. | negl. | negl. | reduce transit peak | Region |
| Compressed | 1 million | - | $75,000 | $.02 - $.08 | - | 1 million | .15% | decrease | - | neg. on HOV | |
| 5.2 Improved Facilities for Low-Energy Vehicles | 216,000 | - | $60,000 | $.30 | - | 216,000 | .03% | decrease | possible increase | neg. effect on traffic | Region |
| 5.3 Education Program to Group Trips | 8.5 million | - | $850,000 | .10 | - | 8.5 million | 1.34% | decrease | decrease | - | Province |

- the estimated base area wide energy consumption includes a large number of rural areas for which the majority of measures analyzed would have little or no impact, (eg. traffic operations measures such as improved signal timings, improved transit services, etc.);

- the estimates of site specific and thus area wide energy savings potential were intended to be conservative.

The following provides a brief discussion of the evaluation results by the five major groupings of measures.

### 3.3.1 Traffic Operations

As illustrated in Exhibit 3.1 the eight Traffic Operations measures deal with the control and regulation of traffic flow. In some instances, the measures fall under the direct jurisdiction of the traffic department and do not require special by-laws (eg. traffic signal timing). In other instances, by-laws may be required (eg. removal of on-street parking) or, budgets may have to be approved (eg. signal coordination extensions).

As illustrated in Exhibit 3.2, the traffic operations measures would result in a 1.1% reduction in fuel consumption or approximately 7.3 million litres of fuel per year. This is generally lower than the potential energy savings that are documented in available literature. In one case, measure 1.1, Alternative Signal Timing Plans, the estimate was considered low (.20% area wide) because it was based on a manual assessment of potential benefits, as opposed to a computer assessment, using the TRANSYT 6C program (in the Detailed Analysis, the computer assessment indicated significantly higher benefits). Another important factor in the overall potential of traffic operations measures, is the effective operating practices of the Traffic Department:

- signal timings are regularly reviewed and, as appropriate, altered;

- there is at present limited on-street parking;

- the traffic signals are integrated with established timing plans;

- there is an extensive one-way street system which minimizes congestion;

- the city has in effect a night-flash program for a significant number of traffic signals.

Even with the relatively small potential, and at this stage, conservative estimate for energy savings, the majority of the measures analyzed are cost-effective. The exceptions are:

- removal of on-street parking if the on-street space must be replaced by a municipally controlled off-street space in a parking facility. In such cases the cost per litre of fuel saved is approximately $1.00. This measure becomes quite cost-effective ($.02/l) if off-street parking is not provided although this is not always possible because of the requirements of affected establishments (eg. local merchants);

- reversible lanes. The cost-effectiveness of a reversible lane is approximately $0.80 per litre of fuel saved;

Generally all of the measures with the exception of 1.3, 1.7 and 1.8 are easy to implement and have minimal impact on other measures. Also, all of the measures would reduce air pollution, generally in proportion to the reducton in fuel consumption.

The replacement of stop signs with yield signs can produce significant energy savings. However, there is the potential to increase accidents and this is assessed in Chapter 4. For this reason clear guidelines are required for the conversion of stop signs to yield signs and 4-way stops to 2-way stops.

### 3.3.2 Transit Related Measures

As illustrated in Exhibit 3.1, ten transit measures were considered in the preliminary analysis, ranging from service improvement measures such as more frequent service during rush hours, to changing passenger demand characteristics through increased promotion of transit. Therefore the energy impact estimates took account of both the direct impacts (i.e. the fuel consumed by HSR) and the indirect impacts (i.e. the fuel savings due to a shift from auto to public transit).

As illustrated in Exhibit 3.2, the transit measures examined could provide an area wide energy savings of approximately 1.3 million litres per year or .2% of the base energy consumption. Two of the measures examined are potentially cost-effective: 2.6 Express Bus Services, and 2.10 Bus Stop Spacing. The majority of the remaining measures are not cost-effective, with, in some cases, the cost per litre saved being as much as $2.30 per litre. With measures 2.3, Increased Service there is an increase in fuel consumption with a cost per litre increase of over $8. Measure 2.4, Increased Promotion, is generally an appropriate measure to implement in that it increases off-peak transit demand thereby increasing the overall efficiency of the transit service. HSR will be implementing an automatic bus passenger information system as part of the communications and control system (CCS) that is currently being designed for implementation within the next two to three years. This type of transit information service has increased ridership significantly in Mississauga and Ottawa.

Although measure 2.10 Bus Stop Spacing and Locations is conceivably cost-effective the analysis did not take into account, other than in a qualitative way, the negative effects of added walk distances to bus stops. Taking this factor into account, the measure would not likely be cost-effective because of the inconvenience to both existing and potential riders.

The most promising transit measure, is that of Express Bus Service. In terms of interaction with other measures, an express bus service to the downtown could be enhanced by higher downtown parking rates and/or fringe parking lots.

### 3.3.3 Legislative Measures

Two legislative measures were considered, 3.1 Controlled Parking and Loading in the Downtown and 3.2 Privately Operated Jitneys or Share Ride Taxis. Both measures have the potential to reduce fuel consumption as well as air pollution and accidents. However, controlled parking or increased parking rates in the downtown would not necessarily be cost-effective if additional transit services were required to accommodate the increased transit

demand. In addition, the majority of the parking in the downtown is privately owned and operated and it would be difficult to legislate higher parking rates for these private lots. Also, it would be politically difficult to institute higher rates on public lots. In assessing loading, it was recognized that on-street loading is necessary for many retail establishments, and although it is preferable to have loading at not peak traffic periods it is not always possible. It was accepted that off-street load facilities should be a requirement of new commercial developments. Because of these reasons, Controlled Parking and Loading in the Downtown would not be a particularly effective project in Hamilton. However, parking availability and cost has an important effect on mode choice and should be considered in conjunction with HOV (High Occupancy Vehicle) measures. Of specific concern is preferential parking for carpoolers and vanpoolers at major employment complexes.

The analysis of shared-ride taxi indicated that the measure would be potentially cost-effective. However, it would require significant changes in the municipal taxi by-laws as well as cooperation with the taxi operators. The latter may be difficult to acquire given the fact that the taxi plates are generally "closed" and have a current market value in Hamiton of $26,000. For this reason, shared-ride taxi operations are recommended as a longer term measure that would be implemented in an evolutionary fashion.

### 3.3.4 HOV (High Occupancy Vehicles) Related Measures

These High Occupancy Vehicle (HOV) measures were assessed as described in Exhibit 3.1. With the exception of Fringe Parking lots which are being implemented by the MTC, none of the measures have been applied in a comprehensive basis.

Of the three HOV measures, preferential treatment of HOV's (i.e. preferential parking rates and locations) is often instituted as part of a carpool and vanpool promotion program, usually in the form of preferential locations at employment centres. Both measures 4.2, Carpool and Vanpool Promotion and 4.3, Fringe Parking, are cost-effective measures which would have

a beneficial impact on fuel consumption, air pollution and accidents. The two measures are complementary in that promotion of carpool and vanpool services would eventually stimulate fringe parking demand and conversely provision of fringe parking lots would increase the need for carpool and vanpool services. A major element of the carpool and vanpool program would be to interest with major employers in establishing a ride-sharing program which would include matching services and priority parking locations for carpoolers and vanpoolers.

### 3.3.5 Other Measures

The three other measures as described in Exhibit 3.1 are directed at travel behaviour: flexible, staggered hours or compressed work weeks requires a change in time of travel; Bikeways requires a change in travel mode; and Grouping of Trips a change in trip frequency.

As summarized in Exhibit 3.2, all three other measures are potentially cost-effective. The single most cost-effective measure based on the assumptions made in the estimates of impacts is an educational program to group trips such as shopping trips, personal business trips, etc. This estimate was, however, based on a simplified analysis with no support documentation from the literature reviewed. Because of this and because it is a measure that is most effectively developed at the provincial level, it is suggested that the province consider undertaking further analysis with a view to developing the necessary education and promotional program.

In reviewing measure 5.1 Staggered, Flexible Hours, or Compressed Work Week, the compressed work week would potentially have the largest energy savings due to the decrease in work trip travel. However, the degree to which it could be implemented in Hamilton would be limited by the ability of the major employers to adopt such a scheme. Because many of the major employers operate on a three-shift basis, seven days a week, the potential may be limited. As for flexible and staggered work hours, this measure is most effective in downtown areas because of the reduction in peak demand with resulting increased transit service efficiency.

## 3.4 MEASURES RECOMMENDED FOR DETAILED EVALUATION

A large number of the transportation management measures reviewed are energy cost-effective and could be implemented immediately and independently. Other measures such as increased transit frequencies during peak periods could be cost-effective eventually as demand is stimulated through other measures (i.e. increased parking rates in the downtown) and as peaking characteristics are altered (i.e. flexible work hours). This interaction of measures is important in the development of a comprehensive transportation energy management program and as such was an important consideration in the identification of measures for more detailed analysis.

The following list summarizes measures that were analyzed in more detail as part of the second phase. The results of this detailed analysis are summarized in Chapter 4.

### 3.4.1 Traffic Operations Measures

Although the majority of traffic operations measures examined are potentially cost-effective, three were forwarded to the detailed analysis phase:

- 1.1 Alternative Signal Timing Plans for a Signal Network: The preliminary estimate of the energy savings of this measure was conservative because of the manual method employed. The detailed analysis involved the application of a traffic optimization program, TRANSYT, 6C, to a selected network of signals for a selected period;

- 1.5 Traffic Signal Flashing has the potential to save energy but also increase accidents. The detailed analysis focussed on accidents and associated costs;

- 1.6 Alternative Traffic Control Measures at Localized Intersections: the three sub-measures examined were converting stop sign control to yield, four-way stops to signal control and replacing fixed time isolated signals with coordinated control or traffic responsive control. In the detailed analysis, accidents and associated costs were considered at some length.

Other cost-effective traffic measures which were not recommended for further analysis are:

- o pedestrian actuated signal control, because the advantages are straightforward and do not require further analysis;
- o the removal of on-street parking because the measure is clearly cost-effective if replacement of off-street parking is not required. The degree to which on-street parking spaces could be removed without replacing the lost spaces is dependent upon a number of factors including availability of off-street capacity and the reaction of local merchants. Since the measure is not cost-effective when costs of off-street replacement are included and since removal of on-street parking at remaining sites without off-street replacement is likely to cause a strong adverse reaction from merchants, this measure was not recommended for further analysis;

### 3.4.2 Transit Measures

Only one transit measure was assessed to be cost-effective in the short-term: 2.6, Express Buses. The detailed analysis of express buses focused on the potential costs of instituting such a service as well as the degree to which the measure would affect adjacent transit routes.

As a general comment on other transit measures not being cost-effective, it is important to point out that the analysis was based upon immediate impacts. Over the longer term many of the measures examined could well be required.

### 3.4.3 Legislative Measures

None of the legislative measures was recommended for the more detailed analysis. Measure 3.1 was not recommended for further consideration because of the limited control over parking and the difficulty in instituting legislation to control private parking lots which account for an estimated 60% of all parking in the Downtown. Measure 3.2, Jitneys or Shared-Ride Taxis was not now recommended for further consideration because of the jurisdictional/institutional impediments. It may, however, be a measure that might evolve as part of a ridesharing program which could eventually include taxi pooling.

### 3.4.4 High Occupancy Vehicle (HOV) Related Measures

All three HOV related measures were recommended for further consideration in the detailed analysis:

- the potential for preferential treatment of HOV's involved contacting major employers and the Parking Authority to identify the potential for priority locations for carpools and vanpools. This measure was considered an integral component of 4.2, Additional Promotion of Carpool and Vanpool services. Other preferential treatment such as HOV by-pass lanes etc., were not recommended for further analysis;

- the potential for 4.2, Additional Promotion of Carpool and Vanpool services were assessed in part through interviews with major employers to determine their willingness to cooperate in a ride sharing program;

- the potential of 4.3, Fringe Parking Lots was assessed through a survey along the major highways to identify unofficial fringe parking which may be occurring and potential locations for fringe parking lots.

### 3.4.5 Other Measures

All three of these measures are potentially cost-effective. However, only 5.1, Staggered, Flexible Hours and Compressed Work Week, and 5.2, Improved Facilities for Low Energy Vehicles, were recommended for further consideration. Measure 5.3, An Educational Program to Encourage Grouping of trips, may be reviewed more appropriately by the Province. For the recommended measures, the detailed analysis included:

- for 4.1, Flexible, Staggered Hours and Compressed Work Week, interviews with major employers to determine the extent to which variable work hours or compressed work weeks are already used and the potential for a more widespread application of the measure;

- for 4.2, Improved Facilities for Low Energy Vehicles, (i.e. Bike-ways), a more detailed assessment of the potential benefits would be undertaken, taking into account potentially high demand areas, and the availability of street or other rights-of-ways to accommodate bike-ways.

# 4 - DETAILED ANALYSIS

Exhibit 4.1 summarizes the measures that were subjected to a more detailed analysis. Generally, the analysis focused on the potential energy savings and the associated costs which for some traffic control measures included a detailed assessment of accidents.

The analysis of the five traffic control related measures was quantitative in nature because of the available data and the accepted methodologies for estimating traffic flow characteristics and associated energy consumption. In estimating the impact of demand altering measures such as carpooling and vanpooling, altered work schedules and fringe parking lots, a more qualitative approach was applied. For this reason, the analysis of these measures includes a more extensive description of background and experience gained elsewhere. Also, specific surveys were undertaken for each of these three measures to determine, as appropriate, employer attitudes, or site specific characteristics. These surveys were important in refining energy estimates and program requirements.

Where appropriate, interaction with other measures was identified, especially if there was potential for a coordinated approach.

## 4.1 ALTERNATIVE SIGNAL TIMING PLANS

In the preliminary analysis of this measure, a manual technique was used to estimate the potential fuel savings associated with the revised signal timing plan on the Mountain. It was estimated that the new plan would result in approximately a 2% reduction in fuel consumption for the affected traffic signals (0.2% area wide). Although the percentage reduction would not be great, the absolute value of the savings on an area-wide basis were estimated to be over 1 million litres per year. The measure was also found to be highly cost-effective at $.01 per litre of fuel saved.

EXHIBIT 4.1

TRANSPORTATION ENERGY MANAGEMENT MEASURES FOR DETAILED ANALYSIS

1. ALTERNATIVE SIGNAL TIMING PLANS

   - apply TRANSYT 6C optimization model to the Mountain signal network

2. TRAFFIC SIGNAL FLASHINGS

   - examine accident and energy savings impacts in more detail

3. TRAFFIC SIGNAL COORDINATION VERSUS ISOLATED FIXED TIME CONTROL

   - analyze energy impacts of coordination versus actuation in more detail

4. REPLACE STOP SIGNS WITH YIELD SIGNS

   - examine accidents and energy impacts in more detail

5. REPLACE 4-WAY STOPS WITH TRAFFIC SIGNALS

   - examine energy impacts in more detail

6. EXPRESS BUS SERVICE

   - examine the degree to which it would affect existing service

7. ADDITIONAL PROMOTION OF CARPOOLING AND VANPOOLING INCLUDING PREFERENTIAL PARKING

   - contact major employers to determine interest and potential

8. FRINGE PARKING LOTS

   - survey potential sites

9. STAGGERED, FLEXIBLE HOURS AND COMPRESSED WORK WEEK

   - survey employers to assess interest

10. IMPROVED FACILITY FOR LOW ENERGY VEHICLES

   - refine estimated impacts

The purpose of the detailed analysis of this measure was to model all of the interconnected signals on the Mountain and determine what reduction in fuel consumption could be attained for the signal network during the normal traffic hour (2 p.m. - 3 p.m. weekday). The TRANSYT6C [1] computer program was used to perform these functions.

## Analysis

The traffic characteristics, existing signal timing plans and network geometrics required to define the input data for the program were obtained from the Department of Traffic. The saturation flows for each link in the network were calculated using an adaptation of the Australian Road Research Laboratory (ARRL) technique. The Traffic Department has used this technique in the past to estimate saturation flows, and feels that it provides a realistic approximation of real world conditions.

A link map of the modelled network is presented in Exhibit 4.1.1.

Initially the TRANSYT6C program was run using a travel speed of 48 km/h (30 mph) for all of the links in the network. The results of a run which used the existing timing plan to simulate present conditions were compared in the field with on-street traffic patterns. Specifically, computer-generated graphs of simulated arrivals and departures on Fennell Avenue, Mohawk Road and Upper James Street were compared with visually observed patterns. These comparisons indicated that as input to the computer program a lower travel speed would be a more appropriate parameter and would result in a better simulation of the existing conditions.

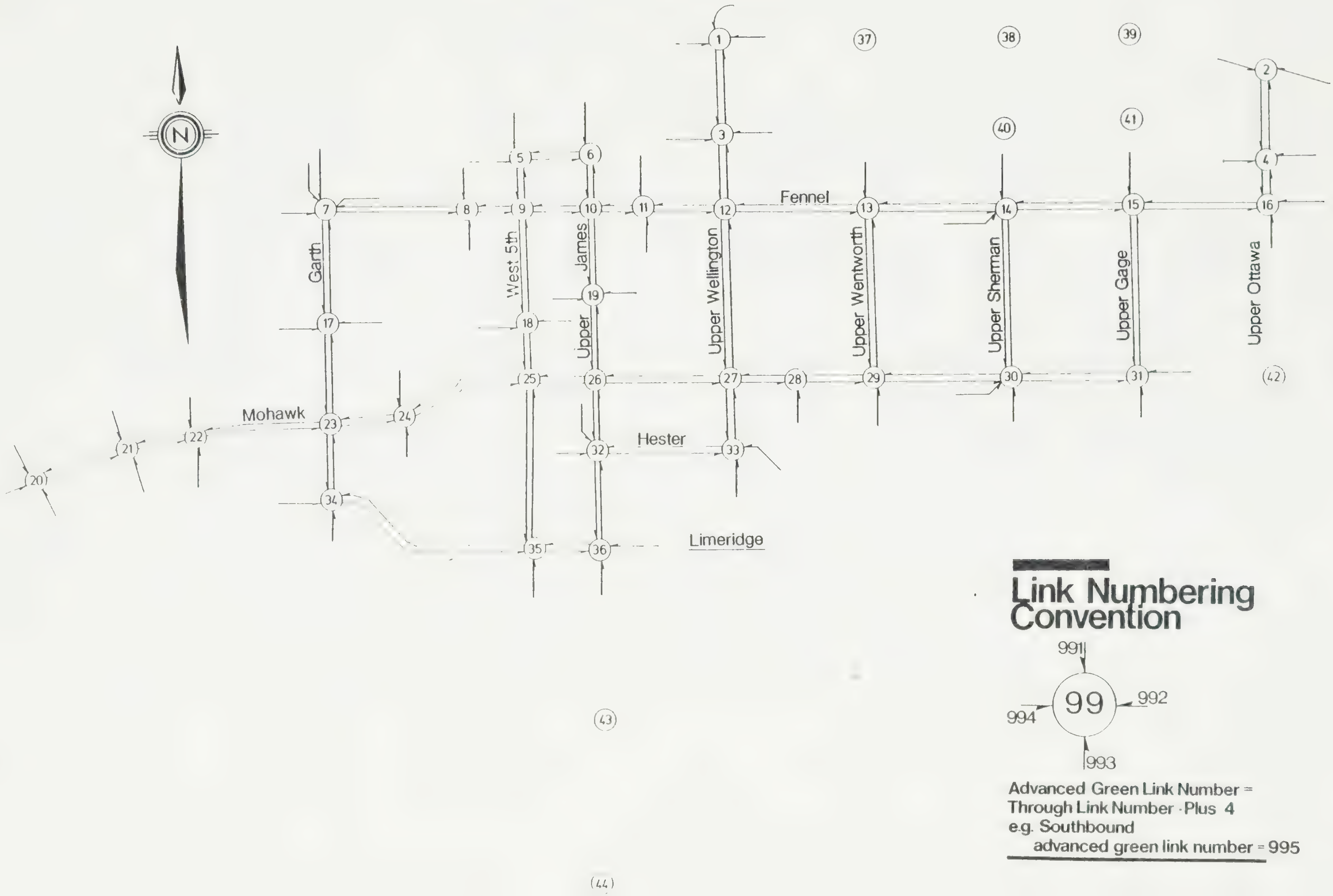
The computer program was subsequently rerun using a travel speed of 39 km/h (24 mph). The simulation results using this speed appeared to match existing conditions more closely and were therefore used as the bench mark

---

[1] TRANSYT6C is a computerized traffic signal optimization program which includes energy consumption estimates and allows for optimization on the bases of energy consumption.

EXHIBIT 4.1.1

MOUNTAIN SIGNAL NETWORK



for further analysis. Although the actual free flow speed on the Mountain appears to be in the range of 26-30 mph, use of 24 mph as input to TRANSYT, produced more realistic flow graphs. This may simply be accounting for some friction and queueing at signalized intersections. Selected results from the runs performed using both speeds are presented in Exhibit 4.1.2. The results are not sensitive to the free flow speed parameter as far as obtaining the optimum cycle length. The variables included are:

- Stops: The average number of vehicle stops per second made during the hour being modelled. When multiplied by 3,600 this value gives the number of stops expected during the normal traffic hour;

- Delay: The total number of vehicle-hours of delay occuring at the signalized section in the network during the normal traffic hour;

- Average Speed: The average speed, including the effects of stops and delays, of the vehicles travelling on the links within the network. The speed of vehicles on source links is not accounted for in this value;

- Fuel Consumed: The number of litres of fuel consumed by the vehicles on the network. This includes fuel consumption on links between connected nodes in the system and excess consumption due to stops and delays at all links.

As shown in Exhibit 4.1.2 the cycle length which results in the lowest fuel consumption for both free-flow speeds is 80 seconds. Generally there is a trade-off between stops and delay as the cycle length is increased. As a result, the optimal cycle length depends on the relative impact of stops and delays on fuel consumption.

In order to obtain a better understanding of why an 80 second cycle length produced the lowest fuel consumption statistics, performance characteristics on four selected arterials were examined in greater detail. Exhibit 4.1.3 presents this comparison for both the through traffic on the arterials and the cross traffic which intersects with the arterials.

EXHIBIT 4.1.2

ALTERNATIVE SIGNAL TIMING PLANS

(TRANSYT 6C RESULTS)

| | | FREE FLOW SPEED = 48 KM/H (30 MPH) | | | | FREE FLOW SPEED = 39 KM/H (24 MPH) | | | |
|---|---|---|---|---|---|---|---|---|---|
| CYCLE LENGTH | TYPE OF RUN | STOPS Veh/Sec | DELAY Veh-Hr | AVG. SPEED km/h | FUEL CONSUMED (litres) | STOPS Veh/Sec | DELAY Veh-Hr | AVG. SPEED km/h | FUEL CONSUMED (litres) |
| 70 | Simulation | 6.87 | 142.24 | 35.89 | 3,576 | 6.57 | 149.10 | 29.93 | 3,598 |
| 70 | Optimization - Offsets Only | 6.15 | 134.32 | 36.36 | 3,516 | 6.24 | 142.17 | 30.27 | 3,564 |
| 70 | Full Optimization | 5.95 | 129.29 | 36.63 | 3,490 | 6.00 | 134.08 | 30.59 | 3,530 |
| 75 | Full Optimization | 5.98 | 138.00 | 36.00 | 3,503 | 5.84 | 137.83 | 30.21 | 3,521 |
| 80 | Full Optimization | 5.57 | 133.74 | 36.11 | 3,464 | 5.52 | 131.66 | 30.59 | 3,482 |
| 85 | Full Optimization | 5.52 | 138.39 | 35.81 | 3,465 | 5.44 | 137.79 | 30.11 | 3,485 |
| 90 | Full Optimization | 5.45 | 143.90 | 35.45 | 3,467 | 5.39 | 143.72 | 29.95 | 3,489 |

EXHIBIT 4.1.3

ARTERIAL PERFORMANCE

| | | | Computer Run | | |
|---|---|---|---|---|---|
| Arterial | Direction | Measure | 70 sec. cycle Simulation | 70 sec.cycle Full Optimization | 80 sec. cycle Full Optimization |
| Fennel Avenue | Through | Stops(veh/sec) | 1.225 | 1.083 | 1.046 |
| | | Delay(veh/hr) | 27.67 | 23.73 | 24.74 |
| | Cross | Stops(veh/sec) | 1.072 | 1.025 | 0.936 |
| | | Delay(veh/hr) | 25.45 | 24.69 | 24.67 |
| Mohawk Road | Through | Stops(veh/sec) | 1.318 | 1.296 | 1.188 |
| | | Delay(veh/hr) | 27.06 | 26.45 | 29.59 |
| | Cross | Stops(veh/sec) | 0.834 | 0.794 | 0.816 |
| | | Delay(veh/hr) | 21.99 | 19.86 | 23.77 |
| Upper James | Through | Stops(veh/sec) | 1.191 | 1.062 | 0.845 |
| | | Delay(veh/hr) | 25.95 | 23.92 | 19.78 |
| | Cross | Stops(veh/sec) | 0.451 | 0.444 | 0.438 |
| | | Delay(veh/hr) | 10.38 | 10.45 | 11.07 |
| Upper Wellington | Through | Stops(veh/sec) | 0.484 | 0.407 | 0.347 |
| | | Delay(veh/hr) | 11.18 | 8.53 | 7.45 |
| | Cross | Stops(veh/sec) | 0.373 | 0.387 | 0.429 |
| | | Delay(veh/hr) | 8.95 | 9.50 | 11.83 |

In all but two of the cases, the 80 second cycle results in a lower number of stops than the 70 second cycle. In addition, 80 second produces significantly lower delay for the through traffic on the north south arterials of Upper James Street and Upper Wellington Street, and similar delay on Fennel Avenue. The improved performance on these arterials is at the expense of increased delay on Mohawk Road.

Based on the intersection spacing of the mountain signal network, the optimum cycle length is 60 seconds along the east-west arterials and 80 seconds in the north-south direction. The reasons why an 80 second cycle length produces the lowest overall fuel consumption for the whole mountain network include:

- o reduced number of stops when compared with shorter cycle lengths. A stop and subsequent acceleration from and back to 40 km/h consumes approximately .029 litres. Forty seconds of delay would result in the same amount of fuel consumption;
- o reduced delay for through traffic on major north-south arterials when compared with shorter cycle lengths;
- o relative to shorter cycle lengths, an 80 second cycle length allows through traffic to receive a higher proportion of green time if the cross street is assigned the minimum green time. This situation occurs at several nodes in the system;
- o since the normal hour was defined as 2:00 to 3:00 p.m., the travel pattern may be similar to the p.m. peak hour pattern which uses a 90 second cycle length;
- o a 90 second cycle length would reduce stops further, but at the expense of a substantial increase in delay and a net increase in fuel consumption.

Before the results of the 80 second cycle length optimization are implemented, an analysis should be performed to determine if differences in the traffic patterns at major intersections for other off-peak time periods significantly affect the optimum signal settings. Also, and as part of any assessment of optimum cycle length, there are other factors, in addition to energy which should be considered; the major factor most commonly assessed is vehicle delay.

Overall, the 80 second optimized signal timing plan for the 36 coordinated signals on the Mountain would save approximately 116 litres of fuel per normal traffic hour, or 3.2% of the existing consumption. Approximately 2,750 of the 3,600 litres of fuel presently consumed during the normal hour would be used even if there were no stops or delays. Therefore the optimum timing plan would reduce the 850 litres of fuel consumed due to stops and delays by 13.6%.

Based on a review of the traffic volumes at a number of intersections in the network, the normal hour accounts for approximately 5.5% of the 24 hour count. Therefore, the revised timing plan would produce fuel savings of 2,100 litres per weekday. Based on work done by the Traffic Department there are approximately 350 equivalent weekdays during a year therefore the annual savings would be 735,000 litres of fuel.

Since there are 36 signals in the Mountain network the savings per intersection would be an average of 20,400 litres per year. The costs of implementation for this measure for the City of Hamilton Department of Traffic were estimated to be $40.00 per signal per timing plan. This amount would cover the salaries of engineering students hired by the Traffic Department to assist with the coding and analysis of the network, and the cost of new hardware required for the signal controllers. The cost does not include time spent on the implementation by Traffic Department staff nor computer charges since neither additional staff nor facilities would be required.

It was felt that these plans would be valid for at least four years since the growth rate of the vehicle kilometres traveled in Hamilton is expected to be low. If this measure is implemented for three separate timing plans and the costs are annualized over four years at a real interest rate of 5%, the annual costs would be $35.00 per signal. Therefore the cost-effectiveness of this measure would be $.002 per litre of fuel saved.

## Conclusions

In the preliminary analysis of this measure, it was estimated that comparable fuel savings could be achieved at 150 signalized intersections in the Hamilton-Wentworth Region and half the average savings could be achieved at another 100 signalized intersections. Therefore, if implemented on an area-wide basis, this measure might result in fuel savings of up to 4 million litres per year. The cost of implementing this measure in the Region would be approximately $30,000.

The implementation of this measure and therefore its cost could be spread over a few years. Priority areas could be identified on the basis of traffic volumes and problems with existing timing plans. During the initial stages of the implementation plan, changes in the traffic patterns due to revised signal timing could be monitored in order to confirm the estimates provided by the computer model.

The greatest fuel savings would result from the first application of this measure. If traffic patterns do not change significantly, subsequent applications would not be as cost-effective. Therefore, decisions on when to perform another revision of the signal time plans would have to be based on on-going monitoring of traffic patterns and on new estimates of the cost-effectiveness of the measure.

It is important to note that the 3.2% potential savings of improved signal timing is low as compared to other published reports. For example, Wagner [(2)] estimated that signal timing optimization would improve travel times by 12% - 16% with an associated energy saving of 4% to 8% for the effected traffic. This lower than expected saving - based on experience elsewhere - indicates that the Traffic Department actively maintains and adjusts the signal timings of the system for efficient operation.

---

[(2)] Overview of the Impacts and Costs of Traffic Control System Improvements, Wagner, F.A., March, 1980.

## 4.2 TRAFFIC SIGNAL FLASHING

In the preliminary analysis of Traffic Signal Flashing operations, it was estimated that this measure could potentially result in a reduction in fuel consumption of approximately 33,500 litres per year, for all signals. It was further estimated that the annual costs of this measure would be $20 to $35 per year per signal, and therefore the cost-effectiveness would range from 10 cents to 50 cents per litre of gasoline saved.

One of the other impacts of this measure which was identified in the preliminary analysis was the potentially significant increase in accidents that could result from the implementation of traffic signal flashing operations.

### Analysis

The detailed analysis of the potential energy impact of traffic signal flashing was performed using data from the intersection of Brant Street and Birch Avenue. The impact of replacing regular fixed time plans with the flashing mode of operations was estimated for:

- Night time hours (existing operations 11:00 p.m. - 6:00 a.m.)
- Evening hours
- Early morning hours
- Daytime off-peak hours.

Fuel consumption was calculated under both fixed time and flashing operations from estimates of stops and delays for all hours under consideration. Webster's formula was used to calculate stops and delays in the case of fixed time operations, while for the case of signal flashing, a formula presented in the Transportation and Traffic Engineering Handbook (equation 7.138, page 307) was used to calculate delay. Stops were set equal to the cross street traffic volumes.

The impact of flashing operations on accidents was estimated from before and after studies conducted by the Department of Traffic of the City of Hamilton. The data was obtained from seven intersections where night flashing operations were discontinued. At these intersections, the collision rate when flashing was operational ranged from - .018 to 2.51 collisions/MVE (million vehicles entering) higher than during the same time of day when fixed time signal control was used. Overall, it was estimated that flashing operations would increase the collision rate by 0.618 collisions/MVE.

Based on the 1979 Hamilton-Wentworth Collision Report, an increase in the collision rate by 0.618 collisions/MVE during flashing operations could result in:

- an increase in damages of $3,400/MVE. This cost is based on $5,500 per accident for property damages, medical costs, loss of incomes and other related costs (1981 dollars);
- if it is assumed that the majority of collisions which would occur during flashing operations would be angle or turning impacts, then 35% or .22 collisions/MVE would be injury producing.

A summary of the fuel savings and accident costs associated with implementing flashing operations during different time periods at Brant and Birch is presented in the table below.

INTERSECTION OF BRANT & BIRCH

Summary of Fuel Savings and Accident Costs

| Time Period of Flashing Operation | Annual Fuel Savings | Annual MVE | Increased Accidents Per Year | Accident Costs | Accident Costs Per Litre Saved | Personal Injury Per Year |
|---|---|---|---|---|---|---|
| 1. Existing (23:00 - 06:00) | 1,200 | .093 | .06 | $318 | $.26 | .02 |
| 2. Morning Extension (06:00 - 07:00) | 1,060 | .120 | .07 | $408 | $.39 | .03 |
| 3. Day Flash (09:00 - 15:00) | 10,580 | 1.003 | .62 | $3,408 | $.32 | .22 |
| 4. Early Evening (17:00 - 20:00) | 4,015 | .372 | .23 | $1,265 | $.32 | .08 |
| 5. Late Evening (20:00 - 23:00) | 1,575 | .130 | .08 | $443 | $.28 | .03 |

## Conclusions

As illustrated in the table above, the accident costs per litre of gasoline saved for this measure ranges from 26 to 39 cents. These accident costs cannot be examined without consideration of the social impacts associated with the potential increase in the number of accidents. These latter impacts would make the measure inappropriate at locations and during time periods where and when the potential for accidents was too large. For example, while the existing flashing operations at Brant and Birch appear to be worthwhile, the implementation of signal flashing during day time off-peak hours at this location might not be justified due to the accident impacts.

Since the annual cost and social impact of the potential increase in accidents would usually be more significant than the annual cost of actually implementing this measure, the evaluation of the measure would have to be done on a site-specific basis. There are 30 to 35 potential sites for this measure in the Region. At those sites where the potential increase in accidents appears to be low, signal flashing may be a worthwhile measure to implement. Alternatively, at other sites the risk of additional accidents could significantly outweigh any potential fuel savings.

## 4.3 SIGNAL COORDINATION OR ACTUATION VS. ISOLATED FIXED TIME CONTROL

Based on the preliminary analysis of this measure, it was determined that either the coordination of traffic signals or the installation of vehicle actuated control would reduce energy consumption relative to isolated fixed time signal control. In the preliminary analysis both coordination and actuation for the traffic signals on Barton Street at Green Road and Millen Road were examined. Excess fuel consumption at the two intersections was estimated using generalized results from other studies. In the detailed analysis, improved estimates of fuel consumption were obtained based on calculated values of stops and delays.

### Analysis

The detailed analysis of this measure consisted of the calculation of stops and delays for the two intersections on Barton Street being examined under the three different types of signal control. Webster's formulae for stops and delays were used in the case of fixed time isolated control.

Webster's delay formula was also used for actuated control. In this calculation the cycle length was set equal to its optimum length. The proportion of stops on any given approach was set equal to the proportion of red time for that direction, assuming that the effect of lost time due to phase changes would be negligible.

In the case of signal coordination, the TRANSYT 6C computer program was used to determine the optimum splits and off-sets associated with the optimum cycle length.

Fuel consumption was calculated manually using the estimated stops and delays under the three different types of signal control. The results of this calculation are presented in the Table below:

Stops, Delays and Fuel Consumption
(based on normal hour)

| Signal Control | Stops | Delay (hrs.) | Fuel Consumption Litres/Hr. | Fuel Consumption Litres/Yr. |
|---|---|---|---|---|
| Actuated | 765 | 3.67 | 37.1 | 212,620 |
| Coordinated Fixed time | 754 | 4.45 | 39.4 | 211,030 |
| Fixed-Time Isolated | 997 | 5.54 | 51.2 | 287,230 |

Note: Litres/hr. x 16.5 normal hrs./day x 340 normal days/yr.

It is estimated that actuated control and signal coordination would respectively cost $10,000 and $20,000 more to install than isolated fixed time control at the two intersections under examination. There would also be additional annual maintenance costs of $250.00 and $65.00 respectively. If the additional capital costs are annualized over 20 years at a real interest rate of 5%, the total annual cost would be $1,015.00 and $1,590.00 for actuated and coordinated control. Therefore, the cost-effectiveness of these types of controls would be 1.4 cents and 2.4 cents per litre of fuel saved respectively.

## Conclusion

Based on the detailed analysis, actuated signal control on Barton Street at Green Road and Millen Road would minimize fuel consumption. This type of control has already been selected for these intersections by the City Traffic Department.

In the preliminary analysis, it was estimated that 30 intersections would be potential candidates for actuation or coordination in Hamilton-Wentworth. Because the intersections analyzed are typical of 30 other locations that could be interconnected or converted to actuated control, potential fuel reduction would be in the order of one million litres per year. The costs presented above were the marginal costs of adding actuation or coordination to a new fixed time control installation. The costs of converting an older intersection may be higher; however, these measures would still be highly cost-effective.

The actual choice of actuated vs. coordinated signal control would have to be done on a site specific basis, and would take into account factors such as proximity of a coordinated signal network, intersection spacings and the type of control equipment presently in place.

## 4.4 REPLACING STOP SIGNS WITH YIELD SIGNS

Based on data from three intersections in the neighbourhood of Crown Point East, the preliminary analysis of this measure indicated that it would be very cost-effective if only the cost of replacing the signs was included. However, since this measure could have a significant impact on accidents, it was further assessed in the detailed analysis in order to quantify the potential increases in accidents.

### Analysis

In order to estimate the differences in fuel consumption between stop and yield control intersections, the following assumptions were made:

- under two-way stop control all vehicles on the cross-street would have to come to a complete stop;
- under yield control only a certain proportion of the vehicles on the cross-street would have to come to a complete stop, while the remaining vehicles on the cross-street would be required only to slow down;
- vehicle delay would be only marginally higher in the case of stop control vs. yield control.

The proportion of vehicles at each of the three intersections being examined that would be required to come to a full stop under yield control was estimated using queueing theory. Savings in fuel consumption were then calculated based on the assumption that vehicles on the cross-street not required to stop would slow to 10 km/h. Overall, it was estimated that 11,400 litres of fuel per year would be saved if the stop signs at the three intersections were replaced by yield signs.

If the intersections were completely uncontrolled, all vehicles would have to slow before entering the intersection to determine the safety of proceeding. Assuming that all vehicles would slow to 20 km/h, it was estimated that the removal of the existing stop control signs at the three intersections being examined would increase fuel consumption by 6,300 litres per year.

As stated earlier, the impact on accidents of converting from stop control to yield control was not considered in the preliminary analysis. Since the intersections in Crown Point East had yield control in the past, it was possible to compare accident statistics for the two types of control. A summary of some of these statistics is presented in the Table below.

Stop vs. Yield - Impact on Accidents at Three Typical Intersections in Crown Point East

| Location | Accidents per year<br>Yield Control | Accidents per year<br>Stop Control | Difference | Additional Accident Costs/Year |
|---|---|---|---|---|
| Fraser & Campbell | 3.80 | 1.22 | 2.58 | 14,200 |
| Britannia & Park Row | 0.25 | 0.25 | 0 | 0 |
| Dunsmure & Graham | 2.00 | 0.68 | 1.32 | 7,250 |
| Total | 6.05 | 2.15 | 3.90 | 21,450 |

Stop vs. Yield - Accident Impact in Crown Point East

| Location | Yield Control | Stop Control | Difference | Additional Accident Costs/Year |
|---|---|---|---|---|
| - 24 intersections | 16.3 | 5.7 | 10.6 | 58,300 |
| - average per intersection | 0.68 | 0.24 | .44 | 2,420 |

The data for the three specific intersections include an average of three years under yield control and six years under stop control. The data for twenty-four controlled intersections in Crown Point East is based on three years of data under each type of control.

As shown in the first table the annual fuel savings of 11,400 litres associated with replacing stops with yields at the three intersections being analysed could cause an additional 3.9 accidents per year. Based on average accident costs of $5,500.00, the cost-effectiveness of the measure would be $1.88 per litre of fuel saved. If the average accident impact for Crown Point East as a whole is used, replacing 2-way stops with yields at the three intersections could cause an additional 1.32 accidents per year. Under this assumption the cost effectiveness of the measure would be $.64 per litre of fuel saved.

## Conclusions

There are over 100 planning neighbourhoods in the City of Hamilton and comparable areas in the other area municipalities. Not all of these neighbourhoods would have as many stop-controlled intersections as Crown Point East, but it is estimated that there would be 1,000 intersections in the region where this measure could be applied. This would result in fuel savings of 3.8 million litres per year, if the traffic characteristics of the intersections were similar to the ones examined in detail.

These fuel savings could be obtained at an expected cost of 440 accidents per year, based on averages from Crown Point East. The financial costs of these accidents would be over $2.4 million per year. More importantly, the social costs would also be very high since an estimated 35% or 155 of these accidents would involve personal injury. Therefore, it is recommended that this measure not be implemented as part of a general program of measures to reduce energy consumption in the Region.

This conclusion may not be warranted in other jurisdictions where the accident impacts of changing from stops to yields could be less significant.

## 4.5 REPLACING FOUR-WAY STOPS WITH TRAFFIC SIGNALS

In the preliminary analysis of this measure, generalized results from other studies were applied to traffic data for the intersection of Limeridge Road and Upper Sherman Avenue. The analysis indicated that replacing the four-way stop control at arterial intersection with fixed time isolated signal control would be a cost-effective approach for reducing fuel consumption. This measure was analyzed in further detail in order to develop more accurate estimates of fuel savings based on calculated values of stops and delays, and to determine if the change in intersection control would have any impact on accidents.

### Analysis

At an intersection controlled by four-way stop signs, all vehicles are required to stop. The vehicle delay associated with this type of control was estimated using queueing theory for the a.m., p.m. and normal hours and then factored up to daily totals.

Webster's formulae were used to calculate the stops and delays which would occur at Limeridge and Upper Sherman if fixed time isolated signals were used to control the intersection. Stops and delays were estimated for the a.m., p.m. and normal hours and then factored up to daily totals. The stops and delays for the three types of control were used to estimate fuel consumption. The table below summarizes the results of this analysis.

Stop, Delays and Fuel Consumption

| Type of Control | Stops Per Day | Total Delay Hrs/Day | Fuel Consumption Litres/Wkdy | Litres/Yr. |
|---|---|---|---|---|
| Four-way stop | 10,523 | 13.12 | 427.4 | 149,600 |
| Fixed-time isolated signal control | 6,370 | 40.14 | 339.2 | 118,700 |
| Two-way stop | 4,479 | 88.23 | 388.5 | 136,000 |
| Savings | | | | |
| - Signal vs. Four-way | 4,153 | -27.02 | 88.2 | 30,900 |
| - Two-way vs. Four-way | 6,044 | -75.11 | 38.9 | 13,600 |

The cost of installing signalized control at an intersection was estimated to be $3,600.00 per year. This cost is made up of $2,000.00 of annual maintenance costs and a capital cost of $20,000.00 annualized over 20 years at a discounted interest rate of 5%. The cost-effectiveness of this measure would therefore be $.12 per litre of fuel saved.

Based on accident data supplied by the Department of Traffic of Hamilton, the average collision rate at twelve intersections controlled by the four-way stop signs was 0.81 collisions per million vehicles entering (MVE). Since the collision rate at signalized intersections in the Region of Hamilton-Wentworth is .80 collisions per MVE, it was concluded that the change in intersection control would not have a significant impact on the frequency of accidents. However, the change in intersection control might have an impact on what type of accidents would occur. Based on data from the 1979 Hamilton-Wentworth Collision Report, 43% of accidents at traffic signals involved personal injuries, while at the stop signs 40% of the accidents were of this type. The difference is not significant and is probably more related to the differences between the characteristics of intersections than to differences in the types of control.

The cost of converting from four-way stop control to two-way stops would be negligible. However, there is some indication that the collision rate at an intersection would be higher under two-way stop control. The average collision rate at 11 intersections which were converted from two-way stops to signalized control went from 0.934/MVE to 0.784/MVE, a decrease of 0.15 collisions per MVE. Since, as indicated earlier, the collision rate at four-way stop controlled intersections is virtually identical to the rate at signalized intersections, conversion from four-way stops to two-way stops could result in an average increase in collision of 0.15/MVE.

Based on the volumes at Limeridge and Upper Sherman and on an average cost per accident of $5,500, the annual accident costs of changing from four-way to two-way stop control would be $3,000/year. Therefore, the cost effectiveness of two-way stops in this case would be $.22/litre of fuel saved.

## Conclusions

It is recommended that signalized control be implemented at all four-way stop intersections with traffic volumes similar to or higher than the volumes at Limeridge or Upper Sherman providing that volumes meet the MTC minimum warrant levels. Also, site specific factors such as geometry and predicted collision rate, should be considered prior to implementation. Based on these criteria, it was estimated that there are nine other potential candidates for this measure in the Region. If the fuel savings at these intersections are comparable to the estimated savings for the test intersection, the total potential fuel reduction would be 309,000 litres per year.

At four-way stop controlled intersections with traffic volumes which are lower than those at Limeridge and Upper Sherman, site specific analysis should be performed to determine whether signalization or two-way stop control results in greater energy savings and to determine the cost-effectiveness of each measure. The potential accident impacts of the measures would also have to be included in the evaluation.

Generally, it can be concluded that four-way stop control increases energy consumption relative to the other two types of control. However, in specific locations this cost may be outweighed by the traffic control benefits of four-way stops.

## 4.6 EXPRESS BUSES

In the preliminary analysis, express buses were identified as an energy saving concept warranting further analysis. That analysis was based on the implementation of a limited-stop express service in a corridor where there were competing surface transit lines. The result of the analysis indicated that there would be a modest increase in ridership but that the ridership could largely come from diversions from other surface routes.

### Analysis

The analysis takes the view that express bus service, if employed, would represent virtually point-to-point service. The investigation assumed that while there may be some limited stops in a collection zone, the majority of the trips would be operated in a closed door, express mode. In order to estimate the impacts of the express service, three express corridors were reviewed. These corridors included:

- A western corridor extending from McMaster University to the downtown.
- An eastern corridor extending from Eastgate Square to the downtown.
- A southern corridor extending from the Mohawk Wellington area to the downtown.

The 1986 person trip table prepared by the Regional Planning Dept. was used as a basis of the investigation. Using the person-trip interchanges and the modal split relationships developed from a surface transit option in the 1976 rapid transit study, estimates were made of both surface transit ridership from the three collector zones as well as anticipated express ridership from the collector zones. In calculating the potential express

ridership, only the residual ridership was attributed to the express service. This means that the express ridership less the surface system ridership was used. Of that residual ridership, 50% was assumed to have been diverted from the automobile. This is probably realistic in the sense that none of the corridor lengths was particularly long. For example, the longest corridor was the eastern corridor which represented a trip length of approximately 8.8 to 9 kilometres one way. The other two corridors represented one way trip lengths of less than 6.5 kilometres.

The results of the analysis are shown in Exhibit 4.6.1 which indicates the anticipated results from a mature system standpoint. The Exhibit indicates that there might be approximately 300,000 annual trips diverted from auto to the three trunk express lines. The net vehicle travel saved would be in the neighbourhood of 1.9 million kilometres. This results in a net saving of 180,000 litres of a fuel at a net cost of close to $70,000. The net costs were based on express buses operating in the peak periods only. There was no additional surcharge for extensive collection facilities that might be required to feed the express service.

Conclusion

The cost per litre saved overall was $.01-$1.74, which indicates that at today's prices, express bus services might now be considered in selected corridors as a part of future energy reduction strategies. From the analysis there are two corridors that could be cost-effective: the McMaster corridor at $.13 per litre saved and the Central Mountain corridor at $.04 per litre saved. Specific corridor savings vary widely and depend on corridor length, orientation of, to the central area, other major generators in the corridor and the efficiency with which the express service can be provided. As a word of precaution, it should be noted that in the calculations the express services were added as a new service in the corridor with no reduction in parallel and perhaps competing services. The possibility exists still that express service in the corridors may serve only to draw ridership from the surface lines. The gestation period for express lines to come to maturity could well be in excess of a year and during that time, energy saving economics of this measure would be less than those estimated.

## EXHIBIT 4.6.1

## EXPRESS SERVICE SUMMARY

| CHARACTERISTICS | AREA: McMASTER 16 | AREA: EASTGATE 23 | AREA: CENTRAL MOUNTAIN 26 | OVERALL |
|---|---|---|---|---|
| Δ Ridership Potential | 207,000 | 162,000 | 416,000 | |
| Diverted | 103,000 | 81,000 | 208,000 | |
| Vehicles km of Travel Saved | 437,000 | 571,000 | 921,000 | 1,924,000 |
| Litres Saved (a) | 80,800 | 107,000 | 173,000 | 360,800 |
| Express Bus Kilometres | 76,200 km | 128,000 km | 121,000 km | 325,200 km |
| Litres Used (b) | 42,800 L | 72,000 L | 68,000 L | 182,800 L |
| Express Bus Cost (c) | $51,000 | $97,000 | $95,000 | |
| Express Bus Revenue (d) | $46,000 | $36,000 | $94,000 | |
| Net Cost (c-d) | $5,000 | $61,000 | $1,000 | $67,000 |
| Net Fuel Saved (a-b) | 38,000L | 35,000 L | 105,000 L | 178,000 L |
| Cost per Litre Saved | $0.13 | $1.74 | $0.01 | $0.37 |

## 4.7 ADDITIONAL PROMOTION OF CARPOOLING AND VANPOOLING

In the Preliminary Analysis it was estimated that additional promotion of carpooling and vanpooling could save 1.2 million litres of gasoline per year with an annual cost of $150,000 - $200,000. Because the estimated cost per litre saved ranged from $.12 to $.17 it was considered cost-effective and worthy of further analysis.

### Background

In Canada, there is limited experience with car and vanpooling promotion. For example, carpool matching services to the general public were implemented in Halifax and Vancouver during the mid 1970's. These projects were not successful largely because they did not place sufficient emphasis on marketing car and vanpooling at major employment centres.

In Ontario, the Provincial Government through the Transportation Energy Management Program (TEMP) has provided a Share-a-Ride service to assist employers in implementing carpool and vanpool programs. This program has achieved some success, but many employers are reluctant to participate in the program because they do not have trained staff to assign to the project (e.g. carpool matching) or they are unwilling to make a commitment to purchase or lease vans.

In Hamilton, the Region of Hamilton-Wentworth in cooperation with the TEMP Share-a-Ride Office sponsored a carpool and vanpool seminar in June 1980, for major employers in the Region. As a result of the seminar one company initiated a vanpool service. Since the seminar, the TEMP Share-a-Ride Office has continued to promote vanpooling and additional companies in the region are seriously considering vanpooling.

In many U.S. Cities, ridesharing offices have been established to coordinate and provide a broad range of ridesharing services including: the promotion of carpools and vanpools to employees of major companies and the general public; vanpool assistance; variable work hour assistance; and transit service information. These projects have been successful with typical benefit cost ratios in excess of 10:1.

A recent study undertaken for TEMP has recommended that an area wide carpool matching service be implemented for the Toronto commutershed in a staged manner, with the first stage being that of a concentrated approach to major employers. Subsequently, the matching service would be expanded to other employers and ultimately the general public. It is expected that this service could achieve considerable benefits with typical costs per litre of fuel saved ranging from $.80 in Phase 1 which includes start-up and development costs to $.16 in Phase 3.

Ridesharing Service

The basic principle of a carpools and vanpool matching service is that individuals with similar travel characteristics will carpool or vanpool if they are provided with appropriate information on other individuals with similar travel characteristics. The motivating force to carpool or vanpool is the travel cost savings for those who participate in the pool. Also, preferential treatment such as preferred parking for carpools is important for a successful carpool program.

The major elements of a carpool and vanpool program include:

- gathering, coding, filing, sorting and distributing information on individuals interested in carpooling. The information is usually gathered through a carpool application form. Computer matching systems are usually used for large volumes of information. The MTC has developed a cross reference system which can be used in conjunction with postal codes to identify origin and destination zones. This is important because it reduces the coding effort. Once the data are on file, individuals are matched by work destination, home location and working times, and matchlists are prepared. Exhibit 4.7.1 is a typical matchlist.

- promotion and marketing of carpooling and vanpooling. Marketing materials are used to indicate the benefits of carpooling and vanpooling, the requirements of a successful pooling arrangement and general information on the services provided by the ridesharing office.

# EXHIBIT 4.7.1

## TYPICAL MATCHLIST

SHARE-A-RIDE OFFICE
248-7272

JAMES SMITH
BMI FABRICATORS
1194 STEELES AVE.
GARYVILLE, ONT.
K1S 2W3

HOME ADDRESS:

4960 YONGE ST.
WESTVILLE, ONT
K1K 3S2

. WILLING TO POOL ON A REGULAR BASIS
. FLEXIBLE WORKING HOURS
(8:30 A.M. TO 5:00 P.M.)
. HAVE A CAR AVAILABLE.
. NON SMOKER

********************************************************************************

THE FOLLOWING IS A LIST OF INDIVIDUALS INTERESTED IN CARPOOLING/VANPOOLING. ALSO THE NAMES OF VANPOOL OPERATORS IN YOUR AREA ARE ALSO PROVIDED AS WELL AS TRANSIT OPERATORS AND THEIR SERVICE INFORMATION NUMBER.

THE CARPOOL COORDINATOR FOR YOUR COMPANY IS JOHN SMITH WHO CAN BE CONTACTED AT 478-5123

THE RIDESHARING OFFICE CAN BE CONTACTED AT 248-7171

********************************************************************************

PEOPLE BELOW ARE LISTED BY APPROXIMATE ORDER OF CONVENIENCE FROM YOUR HOME AND PLACE OF WORK.

********************************************************************************

JOHN DOE
ON PORTLAND AVE (NEAR PARK AVE
AND BROADWAY)

WESTWOOD, ONT
K1K 3S1
WORK PHONE: 225-7983

. WILLING TO POOL ON A REGULAR BASIS
. FLEXIBLE WORKING HOURS
(8:15 TO 4:45)
. HAVE A CAR AVAILABLE
. NON SMOKER

********************************************************************************

ETC.

(UP TO 15 NAMES)

- staff to process application forms and to work with employers in reviewing their transportation problems and developing company specific ridesharing programs. Ridesharing advisors would assume the major responsibility for marketing the matching services to employees and office support staff would code application forms, and prepare and distribute matchlists.

It has been concluded from various ridesharing services in the U.S. that employment-based carpool matching has the highest potential for success and that the services should only be extended to the general public once an adequate data base has been established. The major activities of an employment-centred carpool and vanpool matching service include:

- contacting key companies. Initial contact would be with senior executives to introduce the concept, the services provided by the ridesharing office and acquire approval in principle;
- developing a company-specific program for presentation to middle management to acquire approval to proceed. Typically, the program would make recommendations on preferential treatment (e.g. preferential parking ) use of internal mail systems, approval of marketing materials, agreement of key dates for distribution and return of application forms, etc;
- marketing the service undertaken to employees. The marketing would concentrate on the qualitative and quantitative benefits of pooling. Application forms would be distributed to the employees;
- entering applications onto the data base. Subsequently matchlists would be prepared and distributed to employees with additional information on initiating and maintaining a successful pool;
- maintaining an up-to-date data base;
- group meetings. These would be set up to introduce prospective poolers and to generally outline how a pool should operate with guidelines provided on fare structures, emergency procedures, etc.

Potential Benefits

The potential benefits of a ridesharing service to a particular area is a function of the employment characteristics; the more concentrated the employment and the larger the employment centre size, the greater the potential for success. In Hamilton, there are approximately 50,000 employees in firms with more than 500 employees. Geographically, the greatest concentration of employment is along the Bayfront Area of Hamilton which has 40,000 employees. Because of the concentration of employees both by size of firm and by area, Hamilton exhibits the basic requirements for an employment-based carpool and vanpool matching service. An employment-based service is usually the initial phase, once an adequate data base is established the service could be expanded to smaller firms and subsequently the general public.

As a means of assisting the potential of a carpool and vanpool matching service, a survey was undertaken of the major employers within the Region to determine general information on employer/employee characteristics, and the companies' willingness to participate in a ridesharing service. Approximately 20 major employers were contacted representing some 47,000 employees. The results of the survey are summarized in Exhibit 4.7.2. From the Exhibit, it is evident that there are a number of employment centres with a large number of employees (i.e. in excess of 14,000 employees at specific plants). In many cases plant employees are on a separate day shift from office employees. In spite of the number of plant locations, the industries surveyed are generally well suited to ridesharing services in that the plants are within reasonable proximity to each other. In addition, the shift arrangements are generally compatible between plants (e.g. 7:00 a.m. - 3:00 p.m., 3:00 p.m. - 11:00 .m., 11:00 p.m. - 7:00 a.m.) which is important in matching shift workers from adjacent plants.

Generally, the companies provide free parking to employees. The exceptions are those companies located in the downtown where there is a $20.00 - $30.00 charge per parking space per month. In many cases the parking demand exceeds the available number of spaces.

# EXHIBIT 4.7.2

## SURVEY OF MAJOR EMPLOYERS

A: OVERALL
B: FULL
C: MEDIUM
D: LOW

✓ - YES
X - NO

E: EXCELLENT
G: GOOD
M: MEDIUM
L: LOW
F: POOR

HR - HOURLY
S - SALARY

| | | PART A: EMPLOYER CHARACTERISTICS | | | | | | | | | | | | | | | | PART B: EMPLOYER RESPONSE | | | | | IF INTERESTED WOULD AGREE TO | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | NO. OF HRLY EMPLOYEES IN DAY SHIFT | HRS. OF DAY SHIFT | NO. OF HRLY EMPLOYEES IN AFTERNOON | HRS. OF AFTERNOON SHIFT | NO. OF HRLY EMPLOYEES IN NIGHT SH. | HRS. OF NIGHT SHIFT | TOTAL HOURLY EMPLOYEES | TOTAL SALARIED EMPLOYEES | HRS. OF WORK | TOTAL NUMBER OF EMPLOYEES | CO. PROVIDED PARKING SPACES AVAIL. | CO. PROVIDED PARKING SPACES AVAIL | CHARGE FOR CO. PARKING | OTHER PARKING SPACES AVAIL. | OTHER PARKING SPACES USED | CHARGE FOR OTHER PARKING | EXISTING RIDESHARING PROGRAMS | SUITABILITY TO RIDESHARE PROGRAM | SUITABILITY TO FLEX HRS. PROGRAM | INTEREST IN RIDESHARING OFFICE | SUCCESS ANTICIPATED | LIAISON OFFICER | USE OF MAIL SYSTEM | PREFERENTIAL PKG. | NEIGHBORHOOD MEETINGS |
| COMPANY A | | 250 | 8:00 - 4:00 | 150 | 4:00 - 12:00 | 150 | 12:00 - 8:00 | 750 | 150 | 8:00 - 5:00 | 900 | 200 | A | X | LOTS | B | ✓ | X/✓ | G | L | ✓ | M-L | X | ✓ | ✓ | X |
| COMPANY B | | -- | -- | -- | -- | -- | -- | -- | 500 | 8:00 - 5:00 | 500 | 350 | Z | ✓/X | MORE | C | ✓ | X | L | G | X | - | - | - | - | - |
| COMPANY C | I | -- | -- | -- | -- | -- | -- | -- | 500 | 9:00 - 5:00 | 500 | 100 | A | X | LOTS | B | ✓ | | | | | | | | | |
| | II | 100 | 8:00 - 4:00 | 40 | 4:30 - 12:30 | 20 | 12:30 - 8:00 | 160 | -- | -- | 160 | 160 | B | X | 0 | - | - | | | | | | | | | |
| | III | 50 | 8:00 - 4:00 | 25 | 4:00 - 12:00 | 25 | 12:00 - 4:00 | 100 | 40 | 8:00 - 4:00 | 140 | 150 | A | ✓ | MORE | C | ✓ | | | | | | | | | |
| TOTAL: | | 50 | | 25 | | 25 | | 100 | 700 | | 800 | | | | | | | | | | | | | | | |
| COMPANY D | | 6000 | 7:30 - 3:30 | 2000 | 3:30 - 11:30 | 2000 | 11:30 - 7:30 | 10000 | 4000 | 7:30 - 6:00 | 14000 | 14000 | 13200 | X | SOME | D | ✓ | ✓ | G | M-G | ✓ | G | ✓ | ✓ | ✓ | ✓ |
| COMPANY E | I | 650 | 7:30 - 4:15 | -- | -- | -- | -- | 650 | 50 | 8:30 - 5:00 | 700 | 50 | A | X | LOTS | B-C | $20/ $30 | | | | | | | | | |
| | II | 125 | 7:30 -- 4:15 | | | | | 125 | 5 | 8:30 - 5:00 | 130 | 10 | A | X | LOTS | B-C | $20/ $30 | | | | | | | | | |
| TOTAL: | | 775 | | | | | | 775 | 55 | | 830 | | | | | | | X | M-L | L-F | ✓ | M-L | ✓ | ✓ | X | X |
| COMPANY F | I | -- | -- | -- | -- | -- | -- | -- | 1590 | 8:30 - 4:45 | 1590 | X | - | - | ALL | B | $20/ $30 | | | | | | | | | |
| | II | NA | 7:00 - 3:00 | NA | 3:00 - 11:00 | NA | 11:00 - 7:00 | 12100 | 2170 | 8:30 - 4:45 | 14270 | 1000 | A | X | LOTS | B | $20/ $30 | | | | | | | | | |
| | III | NA | 7:00 - 3:00 | NA | 3:00 - 11:00 | NA | 11:00 - 7:00 | 435 | 110 | 8:30 - 4:45 | 545 | 300 | A | X | LOTS | B | /X | | | | | | | | | |
| | IV | NA | 7:00 - 3:00 | NA | 3:00 - 11:00 | NA | 11:00 - 7:00 | 205 | 60 | 8:30 - 4:45 | 260 | SOME | A | X | SOME | B | $20/ $30 | | | | | | | | | |
| TOTAL: | | | | | | | | 12740 | 3930 | | 16670 | | | | | | | X | M | M | ✓ | NA | ✓ | ✓ | ✓ | ? |
| COMPANY G | I | 150 | 8:00 - 4:30 | -- | -- | -- | -- | 150 | 160 | 8:30 - 4:45 | 310 | 250 | 220 | X | X | - | - | | | | | | | | | |
| | II | 85 | 7:00 - 3:30 | -- | -- | -- | -- | 85 | 25 | 8:30 - 4:45 | 110 | 90 | 80 | X | X | - | - | | | | | | | | | |
| TOTAL: | | 235 | | | | | | 235 | 185 | | 420 | 340 | | | | | | X | M-L | L-F | ✓ | M-L | ✓ | ✓ | X | X |
| COMPANY H | I | NA | 7:00 - 3:00 | NA | 3:00 - 11:00 | NA | 11:00 - 7:00 | 660 | 140 | 8:30 - 4:30 | 800 | NA | B | X | X | - | - | | | | | | | | | |
| | II | 145 | 7:00 - 3:30 | 20 | 3:30 - 12:00 | -- | -- | 165 | 110 | 8:30 - 4:30 | 275 | NA | B-C | X | X | - | - | | | | | | | | | |
| TOTAL: | | | | | | | | 825 | 250 | | 1075 | | | | | | | X | M-G | M-F | ✓ | M-L | ✓ | ✓ | ✓ | ✓ |
| COMPANY I | | NA | 7:00 - 3:00 | NA | 3:00 - 11:00 | -- | 11:00 - 7:00 | 1200 | 500 | 8:15 - 4:45 | 1700 | NA | B-C | X | NA | NA | NA | | | | | | | | | |

# EXHIBIT 4.7.2
(CONTINUED)

A: OVERALL
B: FULL
C: MEDIUM
D: LOW

✓ - YES
X - NO

E: EXCELLENT
G: GOOD
M: MEDIUM
L: LOW
P: POOR

HR - HOURLY
S - SALARY

| | | PART A: EMPLOYER CHARACTERISTICS | | | | | | | | | | | | | | | | PART B: EMPLOYER RESPONSE | | | | | IF INTERESTED WOULD AGREE TO | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | NO. OF HRLY EMPLOYEES IN DAY SHIFT | HRS. OF DAY SHIFT | NO. OF HRLY EMPLOYEES IN AFTERNOON | HRS. OF AFTERNOON SHIFT | NO. OF HRLY EMPLOYEES IN NIGHT SH. | HRS. OF NIGHT SHIFT | TOTAL HOURLY EMPLOYEES | TOTAL SALARIED EMPLOYEES | HRS. OF WORK | TOTAL NUMBER OF EMPLOYEES | CO. PROVIDED PARKING SPACES AVAIL. | CO. PROVIDED PARKING SPAC. USED | CHARGE FOR CO. PARKING | OTHER PARKING SPACES AVAIL. | OTHER PARKING SPACES USED | CHARGE FOR OTHER PARKING | EXISTING RIDESHARING PROGRAMS | SUITABILITY TO RIDESHARE PROGRAM | SUITABILITY TO FLEX. HRS. PROGRAM | INTEREST IN RIDESHARING OFFICE | SUCCESS ANTICIPATED | LIAISON OFFICER | USE OF MAIL SYSTEM | PREFERENTIAL PKG. | NEIGHBOURHOOD MEETINGS |
| COMPANY J | 1. | 300 | 7:00 - 3:30 | 250 | 3:30 - 12:00 | 100 | 12:00 - 7:00 | 650 | 210 | 8:00 - 4:30 | 860 | 718 | B-C | X | 0 | - | - | X | M-L | L | ✓ | L | ✓ | ✓ | ✓ | ✓ |
| COMPANY K | | 500 | 8:00 - 5:00 | -- | -- | -- | -- | 500 | 500 | 8:00 - 4:30 | 1000 | 1500 | C | X | SOME | 0 | ✓ | X | M-L | L-F | ✓ | L | ✓ | ✓ | ✓ | ✓ |
| COMPANY L | I | 1050 | 7:00 - 3:30 | 300 | 3:30 - 11:30 | 50 | 11:30 - 7:30 | 1400 | 500 | 8:30 - 5:00 | 1900 | 2080 | B-C | X | NA | - | - | | | | | | | | | |
| | II | 30 | 7:30 - 4:00 | 10 | 4:00 - 12:30 | -- | -- | 40 | 60 | 7:30 - 7:30 | 100 | 85 | B | X | NA | - | - | | | | | | | | | |
| | III | -- | -- | -- | -- | -- | -- | -- | 110 | 8:30 - 4:45 | 110 | 140 | C | X | NA | - | - | | | | | | | | | |
| | IV | 65 | 8:30 - 5:00 | 15 | 11:00 - 7:30 | -- | -- | 80 | 90 | 8:30 - 5:00 | 170 | 150 | B-C | X | NA | - | - | | | | | | | | | |
| | V | -- | -- | -- | -- | -- | -- | -- | 220 | 8:30 - 5:00 | 220 | 180 | B | X | NA | - | - | | | | | | | | | |
| TOTAL: | | 145 | | 325 | | 50 | | 1520 | 980 | | 2500 | 2635 | | | | | | X | M-G | HR-F S-G | ✓ | M-L | X | ✓ | ✓ | ✓ |
| COMPANY M | | 320 | 7:00 - 3:30 | 40 | 3:00 - 11:00 | 40 | 11:00 - 7:00 | 400 | 100 | 8:00 - 4:30 | 500 | 550 | C | X | 0 | - | - | X | L | L-F | X | - | - | - | - | - |
| COMPANY N | | 300 | 7:30 - 4:00 | -- | -- | -- | -- | 300 | 100 | 8:15 - 4:15 | 400 | 950 | D | X | ✓ | WHEN BUSY | ✓ | X | G-L | L | ✓ | M-L | ✓ | ✓ | ✓ | ✓ |
| COMPANY O | I | 100 | 7:00 - 3:30 | -- | -- | -- | -- | 100 | 100 | 8:30 - 3:30 | 200 | 200 | B-C | X | 0 | - | - | | | | | | | | | |
| | II | 225 | 7:00 - 3:30 | -- | -- | -- | -- | 225 | 25 | 8:30 - 3:30 | 250 | 200 | B | X | 0 | - | - | | | | | | | | | |
| TOTAL: | | 325 | -- | | | | | 325 | 125 | | 450 | 400 | | | | | | X | M-L | - | X | - | - | - | - | - |
| COMPANY P | I | 15 | 7:00 - 3:00 | 5 | 3:00 - 11:00 | 5 | 11:00 - 7:00 | 25 | 150 | 8:15 - 4:45 | 150 | 200 | C | X | SOME | D | ✓ | | | | | | | | | |
| | II | 125 | 7:00 - 3:30 | 25 | 3:00 - 11:00 | 25 | 11:00 - 7:00 | 175 | 25 | 8:15 - 4:45 | 25 | 200 | C | X | SOME | D | ✓ | | | | | | | | | |
| TOTAL. | | 140 | | 30 | | 30 | | 200 | 175 | | 375 | 400 | | | | | | X | L | L-F | X | - | - | - | - | - |
| COMPANY Q | | 125 | 7:30 - 4:00 | -- | -- | -- | -- | 125 | 50 | 7:30 - 4:00 | 175 | 150 | 100 | X | 0 | - | - | X | M-L | L-F | ✓ | M-L | ✓ | ✓ | X | ✓ |
| COMPANY R | | 190 | 7:00 - 3:30 | 60 | 3:00 - 11:00 | 60 | 3:00 - 11:00 | 300 | 115 | 8:00 - 4:30 | 425 | 250 | | | 0 | - | - | X | M-L | L-F | ✓ | M-L | ✓ | ✓ | ✓ | ✓ |
| COMPANY S | I | 220 | 7:00 - 3:00 | 180 | 3:00 - 11:00 | -- | -- | 400 | 400 | 8:30 - 4:30 | 800 | 700 | A | X | SOME | C | ✓ | | | | | | | | | |
| | II | 360 | 7:00 - 3:00 | 340 | 3:00 - 11:00 | -- | -- | 700 | 200 | 8:30 - 4:30 | 900 | 700 | A | X | SOME | C | ✓ | | | | | | | | | |
| | III | -- | -- | -- | -- | -- | -- | -- | 50 | 8:30 - 4:30 | 50 | NA | B-C | X | NA | - | - | | | | | | | | | |
| | IV | 20 | 7:00 - 3:00 | 15 | 3:00 - 11:00 | -- | -- | 35 | 5 | 8:30 - 4:30 | 40 | NA | B-C | X | NA | - | - | | | | | | | | | |
| | V | 130 | 7:00 - 3:00 | 120 | 3:00 - 11:00 | -- | -- | 250 | 100 | 8:30 - 4:30 | 350 | NA | B-C | X | NA | - | - | | | | | | | | | |
| | VI | -- | -- | -- | -- | -- | -- | -- | 70 | 8:30 - 4:30 | 70 | NA | B-C | X | NA | - | - | | | | | | | | | |
| | VII | 255 | 7:00 - 3:00 | 245 | 3:00 - 11:00 | -- | -- | 500 | 500 | 8:30 - 4:30 | 1000 | 700 | A | X | MORE | C | ✓ | | | | | | | | | |
| TOTAL | | 985 | | 900 | | | | 1885 | 1325 | | 3210 | | | | | | | ✓ | M-G | M | ✓ | M | ✓ | ✓ | [illegible] | ✓ |
| | | | | | | | | | | | 46790 | | | | | | | | | | | | | | | |

With the exception of three companies that are currently giving some consideration to instituting a vanpool service, none of the companies provide ridesharing services. In most cases, the companies were interested in a carpool and vanpool matching service. The expected level of success (as stated by the company representative) of a ridesharing office ranges from low to good. For the most part, those companies that expressed an interest in ridersharing office would be willing to appoint a liaison officer to coordinate activities, provide the internal mail system for the distribution and collection of application forms, provide preferential parking and allow employees to attend a group meeting.

The employer response to the concept of a ride-sharing office was generally favourable with some specific comments being that a ridesharing service would be most appropriate for the area because of the distances that some employees must travel (e.g. from St. Catharines) and the concentration of large firms.

Estimates were made of the possible benefits of a carpool and vanpool matching service for the major employment centres in the Region based on the results of the survey. It was assumed that only those firms surveyed who stated a positive interest would participate. A subsequent estimate was made of the benefits of general service to major employers and the general public (Phase 2). Exhibit 4.7.3 summarizes the estimated benefits in terms of fuel savings and travel cost savings. The Exhibit also summarizes key assumptions as they relate to auto occupancies achieved as a result of carpool matching services, travel distances, fuel consumption rates etc. The assumptions are conservative by comparison with similar matching services in U.S. cities.

As indicated in the exhibit, the estimated annual fuel savings in Phase 1 are 777,000 litres and 1.1 million litres in Phase 2.

Costs

Based on the described activities in dealing with major employers and employees, and the number of larger companies, estimates were developed for staff, and marketing and computer service requirements:

EXHIBIT 4.7.3

ESTIMATED BENEFITS OF CAR AND VANPOOL SERVICE

| Car and Vanpool Matching | No. of Employees | No. of Applicants | Forming Pools Etc. | Annual Litres Of Fuel Saved | Annual Cost Of Fuel Saved | Annual Travel cost Savings |
|---|---|---|---|---|---|---|
| Phase 1 | 45,000 | 13,500 | 1,080 | 777,200 | $295,000 | $ 845,550 |
| Phase 2 | 65,000 | 19,500 | 1,560 | 1,120,000 | 426,900 | $1,220,000 |

Assumptions*

- 30% of the employment approached complete an application form. (The typical range of participation is 30% to 40%.)
- Of those who apply, 8% form a carpool or increase the size of a carpool. (The typical range of formation is 8% to 10% and in some cases as high as 12%.)
- The average auto occupancy for those participating increases from 1.2 to 2.8
- The average round trip commuting distance is 40 kilometres. (Approximately 35% of the auto commuters in Hamilton travel more than 35 kilometres round trip. The average round trip is in excess of 48 kilometres for auto users travelling more than 35 kilometres.)
- Fuel consumption rate is 5.8 kilometres/litre.
- Fuel costs $.38 per litre.
- Average travel cost 18.5¢/kilometre.
- 230 commuting days.
- After carpooling trip length increased by 1.6 kilometre.
- The average carpool life is assumed to be 12 months (experience in U.S. indicates that the average life of a carpool is approximately 2 years).

* Source: Area Wide Car and Vanpool Matching and Transit Service Information, IBI Group, September, 1981. Unpublished TEMP Report.

- a project coordinator would be required to direct and assist with various elements of the project to meet with senior company officials;

- two ride-sharing advisors would be required to meet with and assist major employers on an on-going basis;

- two office support staff would be required to process applications and prepare matchlists;

- marketing and computer services would be provided on an as-required basis.

The estimated annual costs for Phase 1 and 2 are summarized in Exhibit 4.7.4. The additional costs for Phase 2 reflect added promotional activities and support staff. Based on these costs and the estimated fuel savings, the resulting cost per litre of fuel saved ranges from approximately $.28 in Phase 1 to $.24 for Phase 2.

The start-up costs for a carpool and vanpool matching service could be kept to a minimum by using software and marketing materials that are to be developed for the Metro Toronto area-wide matching service. Refinements would be required to the software to allow for improved handling of shift work and the postal code for the area would have to be translated to a geo-code reference system used for matching locations. It is estimated that these start-up costs would be approximately $35,000 and would require approximately 6 months.

Conclusions

Based on potential fuel savings of an area wide carpool and vanpool matching service and the cost per litre of fuel saved, a carpool and vanpool matching project would be beneficial in Hamilton. However a trial application would provide a basis by which to assess the ultimate potential of the service in Hamilton, and the Region should pursue the implementation of this measure.

## EXHIBIT 4.7.4

## ESTIMATED ANNUAL COSTS

| | PHASE 1 | PHASE 2 |
|---|---|---|
| Staff | $ 180,000 | $ 220,000 |
| Marketing Materials | 12,000 | 15,000 |
| Computer Costs | 10,000 | 15,000 |
| General Expenses | 13,000 | 15,000 |
| | $ 215,000 | $ 265,000 |

## 4.8 FRINGE PARKING LOTS AS CARPOOL AND VANPOOL ASSEMBLY AREAS

In the preliminary analysis of fringe parking lots, it was estimated that nine fringe parking lots (one for each major transportation corridors leading to Hamilton) would result in an annual saving of approximately 350,000 litres of gasoline due to carpooling. It was further estimated that the annual cost of these parking lots would range from $46,000 to $64,000 with a resulting annual cost per litre of fuel saved of between 13¢ and 18¢. It was therefore recommended in the preliminary analysis that a more detailed assessment be undertaken of fringe parking lots through a survey along the major highways to identify locations where unofficial parking is now occurring and to identify potential locations where fringe parking lots could be constructed.

### Background

Fringe parking lots are primarily directed at the longer distance commuters. For example, a survey of the users of MTC fringe parking lots indicated that the average travel distance for fringe parking lot users was approximately 70 kilometres between the place of residence and the place of work. The average distance between the fringe parking lot and the place of work was approximately 47 kilometres. In the Hamilton area, these travel distances may be somewhat shorter, but it nonetheless indicates that the major demand for fringe parking lots for people employed in Hamilton would be from urban areas such as St. Catharines, Niagara Falls, Brantford, Cambridge, Burlington, Oakville and Mississauga. For those employees who work in Hamilton but commute from the east along the QEW, three fringe parking lots have been provided at: the QEW and Guelph Line; the QEW and Ford Drive; the QEW and Winston Churchill Blvd. The MTC has also provided a fringe parking lot at the interchange of 401 and Highway 6.

Fringe parking lots could also be used by residents of the Region of Hamilton-Wentworth who commute longer distances to other major employment centres such as Metropolitan Toronto. To some extent, this need is now served by the fringe parking lot at the QEW and Guelph Line. It would be reasonable to expect that a larger share of the commuters could be captured by providing more lots in closer proximity to major residential areas within the

Region. Of particular concern in this regard is the QEW south of the Burlington Skyway and Highway 403 west of the QEW.

### Survey of Potential Sites

A survey was undertaken to identify potential fringe parking lot locations including possible sites for new construction as well as sites that might be leased. Also as part of the survey, an attempt was made to identify locations where unofficial parking was occurring by commuters. It is important to point out that the survey was not intended to be all inclusive but to provide a general indication of potential fringe parking lot locations.

In conducting the survey, information was gathered on each location. Generally, the information related to location, size, exposure and accessibility, availability of services etc. For each site a survey form was completed and photographs taken to provide basic information for future reference. The survey forms for the sites surveyed including photographs are contained in a separate document.

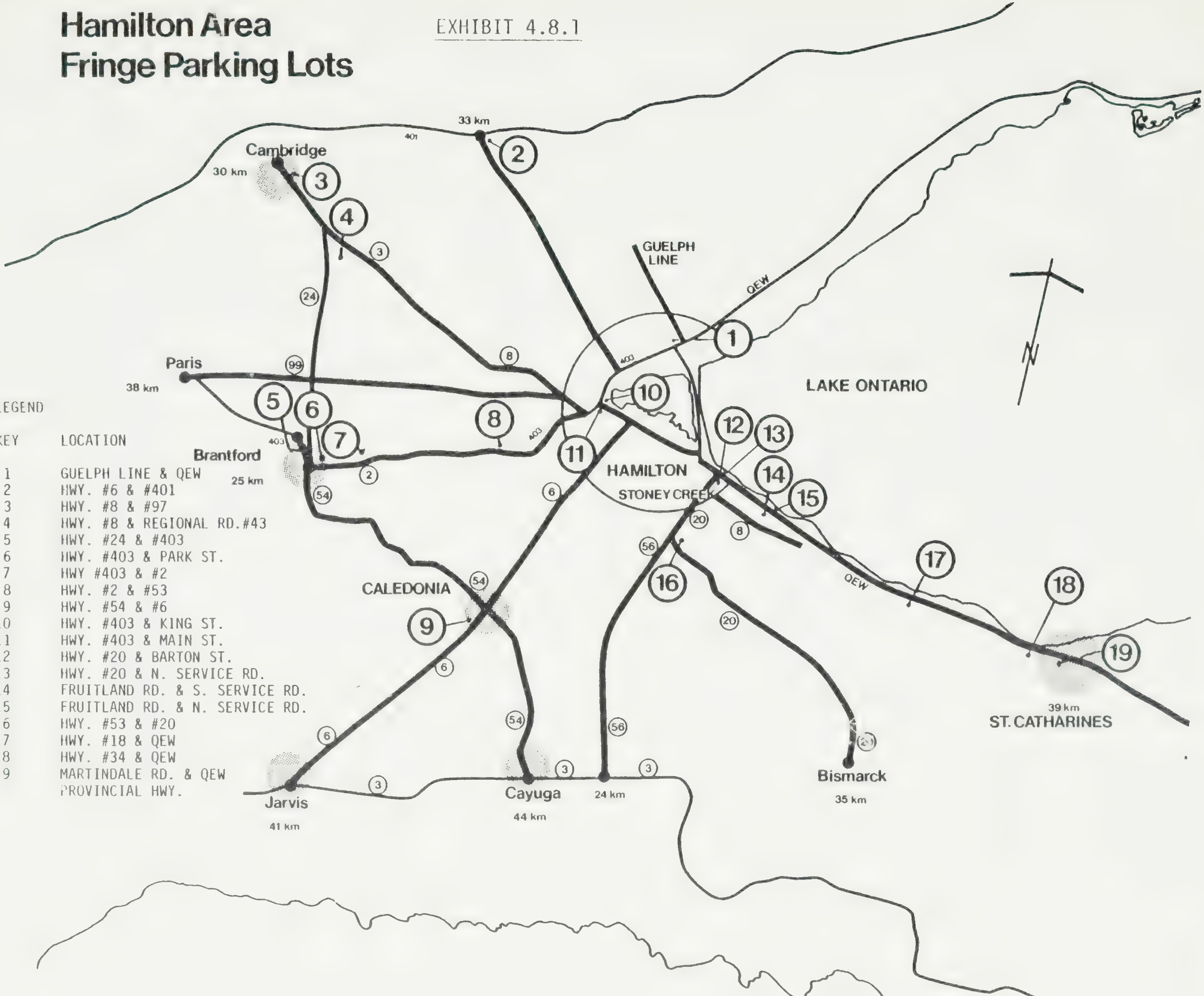
In total 19 potential fringe parking lot locations were identified as illustrated in Exhibit 4.8.1 with the site characteristics summarized in Exhibit 4.8.2. From the latter, it is evident that two sites examined are existing fringe parking lots that are currently operated by the MTC (the QEW-/Guelph Line lot and the Highway 6/Highway 401 lot). These lots were surveyed to provide an indication of the extent of demand for fringe parking lots. Generally, there has been a steady growth in demand as witnessed by the lot at Highway 401 and Highway 6 where in 1980 this was an unofficial lot with approximately four to eight cars parked, it is now used by about 40 vehicles daily.

As for the other sites, the majority have an adequate size (i.e. can accommodate more than 25 vehicles), are easily accessible, have good exposure, and have the necessary services (e.g. Hydro and Bell).

Some of the sites identified also included unofficial parking. Generally, these locations were at interchanges along the QEW where it was relatively easy to identify parked vehicles that belong to commuters. The

# Hamilton Area Fringe Parking Lots

EXHIBIT 4.8.1




LEGEND

| KEY | LOCATION |
|---|---|
| 1 | GUELPH LINE & QEW |
| 2 | HWY. #6 & #401 |
| 3 | HWY. #8 & #97 |
| 4 | HWY. #8 & REGIONAL RD.#43 |
| 5 | HWY. #24 & #403 |
| 6 | HWY. #403 & PARK ST. |
| 7 | HWY #403 & #2 |
| 8 | HWY. #2 & #53 |
| 9 | HWY. #54 & #6 |
| 10 | HWY. #403 & KING ST. |
| 11 | HWY. #403 & MAIN ST. |
| 12 | HWY. #20 & BARTON ST. |
| 13 | HWY. #20 & N. SERVICE RD. |
| 14 | FRUITLAND RD. & S. SERVICE RD. |
| 15 | FRUITLAND RD. & N. SERVICE RD. |
| 16 | HWY. #53 & #20 |
| 17 | HWY. #18 & QEW |
| 18 | HWY. #34 & QEW |
| 19 | MARTINDALE RD. & QEW |
| | PROVINCIAL HWY. |

## EXHIBIT 4.8.2

## SUMMARY OF FRINGE PARKING LOTS

| LOCATION | EXISTING LOT ON SITE | UNOFF. CARPOOL PARKING | TOTAL SPACES | AVAIL. SPACES | POSSIBLE EXPANSION | EXPOSURE | ACCESSI-BILITY | SURFACE TYPE | | | DRAINAGE | ADJC. HYDRO | ADJC. BELL | ADJACENT TRANSIT | | IMPACT ON ADJACENT PROPERTY | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | ASPHALT | GRAVEL | SOIL | | | | LOCAL | COMMUTER | | |
| Guelph Line and QEW (Burlington) | Yes | No | 420 | 310 | No | Good | Good | Good | | | Good | Yes | Yes | Yes | No | No | o well marked out with signage on both Guelph Line and QEW<br>o bus route comes right into lot |
| Hwy.6 South of 401 (Morriston) | Yes | No | 50 | - | No | Good | Good | Good | | | Good | Yes | Yes | No | No | No | o free parking (MTC) 40 cars parked |
| Hwy.8 & 97 (Cambridge) | Yes | Yes | 100's | 100+ | No | Good | Good | Good | | | Good | Yes | Yes | Yes | No | No | o unlimited potential |
| Hwy.8 & Regional Road 43 | Yes | Yes | 5 | 4 | No | Fair | Good | | | Good | Good | Yes | Yes | No | No | Yes | o backs onto fenced off private property |
| Hwy.24 & 403 (Brantford) | Yes | Yes | 30-50 | 25-30 | No | Good | Good | Fair | | | Good | Yes | Yes | Yes | No | No | o abundance of potential sites in this area - plaza lots, etc. |
| Hwy.403 & Park St. (Brantford) | Yes | Yes | 1000's | 100+ | No | Good | Good | Good | | | Good | Yes | Yes | Yes | No | No | o unlimited potential |
| Hwy.403 & 2 (Brantford) | Yes | Yes | 50+ | 46+ | No | Fair | Good | Fair | | | Fair | Yes | Yes | No | No | No | |
| Hwy 2 & 53 | Yes | Yes | 20-30 | 19-29 | Yes | Good | Good | | Fair | | Fair | Yes | Yes | No | No | No | o 1 car parked in vacant space |
| Hwy.54, 1 Mile West of 6 | Yes | Yes | 20-25 | 15-20 | No | Fair | Fair | | Good | | Fair | Yes | No | No | No | Yes | o 5 cars parked<br>o all other available spaces in area in two pay parking lots |
| Hwy.403 & King St. (Hamilton) | Yes | No | 80 | 70 | No | Fair | Fair | Good | | | Good | Yes | Yes | Yes | Yes | No | |
| Between King, Main St. & 403 (Hamilton) | No | No | - | - | - | Fair | Fair | | | Good | Good | Yes | Yes | Yes | Yes | No | o potential site would require paving |
| Hwy.20 & Barton St. (Hamilton) | Yes | No | 100's | 100's | No | Good | Good | Good | | | Good | Yes | Yes | Yes | No | No | |
| Hwy.20 & North Service Road (Hamilton) | Yes | No | 100's | 100's | No | Fair | Good | | Good | | Good | Yes | No | No | No | No | o parking pass available for $30/year |
| Fruitland Rd. & South Service Road | No | No | 100+ Potential | - | - | Good | Good | | | Good | Fair | Yes | Yes | No | No | No | o land designated on south side of South Service Road - being cleared for lot |
| Fruitland Rd. & North Service Road | No | No | 100+ Potential | - | - | Good | Good | | | Good | Good | Yes | Yes | No | No | No | |
| Hwy.53 & 20 | Yes | No | 50-100 | 36+ | Yes | Good | Good | | Fair | | Good | Yes | No | No | No | No | o 14 cars parked |
| Hwy.18 & QEW (Beamsville) | No | No | 20 | 17 | No | Good | Good | | | Good | Good | Yes | No | No | No | No | o 3 cars parked |
| Hwy.34 & QEW | No | Yes | - | - | No | Good | Good | Good | | | Good | Yes | No | No | No | No | o 2 cars parked<br>o a lot of green space available and no other potential sites |
| Martindale Rd. & QEW (St. Catharines) | No | Yes | 20-25 | 20-25 | No | Good | Good | | Fair | | Good | Yes | No | No | No | No | o two cars parked at 5 p.m., must be more parked during the day |

other location where fringe parkers were identified was at the intersection of Highway 53 and Highway 20 where there is a large unofficial parking lot in an open field. It was not possible to clearly identify unofficial parking at other locations throughout the area because commuters could not be distinguished from shoppers, etc. in the more urbanized areas.

Based on the survey, fringe parking lots should be established in the areas as indicated in Exhibit 4.8.3.

The first three areas are adjacent to Cambridge and Caledonia. Unofficial parking was not identified in these areas because of the commercial retail development along the highways. For this season, it would seem most appropriate that during the initial period, space be leased from retail establishments to test the suitability of fringe parking lots in each of the areas. Leasing would minimize the capital investment and in most cases could be arranged for quickly. It is estimated that 20 spaces in each area would be adequate.

Another recommended area consists of the interchanges between Highway 6 and Mohawk Road along Highway 403. In this area, Highway 403 carries up to 40,000 vehicles per day and would provide a suitable meeting area for commuters in Dundas, Hamilton and areas west who are destined to Oakville, Mississauga or Toronto.

Another potential area for a fringe parking lot is at the intersection of Highway 20 and Highway 53. At present, there is a gravelled parking lot on the MTC right-of-way which is used as an unofficial fringe parking lot. This lot could acquire official status very inexpensively, simply by providing an asphalt surface to the existing gravel base and installing advance notice signs on the major approaches.

Another area that is well suited to a fringe parking lot is the area adjacent to the interchange of Highway 20 and the QEW. This area would provide a natural meeting place for residents of Hamilton, Stoney Creek and areas to the south who commute to Burlington and other areas east.

## EXHIBIT 4.8.3

## RECOMMENDED FRINGE PARKING LOTS

| | No. of Spaces |
|---|---|
| South of Cambridge Along Highway 8 | 20* |
| East of Brantford along Highway 2 | 20* |
| Caladonia Near Intersection of Highway 6 and Highway 54 | 20* |
| Interchange Along Highway 403 Between 6 and Mohawk Road | 50-100 |
| Intersection of Highway 20 and Highway 53 | 50 (An Existing Unofficial Site) |
| Highway 20 and QEW Interchange | 50 |
| QEW and Regional Road 18 | 25 |
| QEW and Martindale Road, St. Catharines | 25 |
| | 260-310 |
| | (60 spaces to be leased) |

* These spaces should be leased.

The latter two potential locations for fringe parking lots are at interchanges along the QEW. The first at Highway 18, is already used as an unofficial lot by three commuters. The second area is at the interchange of Martindale Road and the QEW in St. Catharines. In the survey that was undertaken, two unofficial parkers were identified along the shoulder of the road (in a subsequent survey it was determined that 12 vehicles were parked along the road).

## Costs and Energy Savings

Exhibit 4.8.4 summarizes the estimated annual capital and operating costs of 260-310 fringe parking spaces that are recommended. The capital costs are based on a construction cost of $1,500 per space with a discount rate of 5%, reflecting the real cost of capital. It was assumed that 60 spaces could be leased at $200 per space per year. Including maintenance costs, the total estimated annual costs would range from $61,000 to $73,000, approximately $235.00 per space per year.

The estimated annual energy savings are approximately 321,000 litres of gasoline. This estimate is based on: an occupancy rate of 70% for the lot; round trip commuting distances of 94 km; and 50% of users being commuters who previously drove alone. These assumptions are based on surveys conducted by the MTC.

The cost per litre of fuel saved would range from 19 to 23 cents.

## Conclusions

Because fringe parking lots would result in cost-effective energy savings the Region should approach the MTC to consider constructing parking lots in areas where unofficial parking is now occuring, and where there is no commercial/retail parking available. At other locations where there is a possible demand and where existing parking is available the MTC should negotiate leases with the lot owners. This would minimize the financial risk and provide for demand to be monitored. Fringe parking lots could also be promoted through an area wide carpool and vanpool matching service.

## EXHIBIT 4.8.4

## ESTIMATED COSTS AND ENERGY SAVINGS

| | |
|---|---|
| Capital Costs<br>(@ $1,500/parking space) | $300,000 - $375,000 |
| Annualized Capital Costs<br>(10 yr. @ 5%*) | $39,000 - $48,500 |
| Lease Costs<br>(assumed cost of $200.00/space/yr.) | $12,000 |
| Maintenance Costs<br>($50.00/space/yr.) | $10,000 - $12,500 |
| Total Annual Cost | $61,000 - $73,000 |

Annual Energy Savings:

Assuming 70% occupancy, and that 50% of the users previously drove alone annual energy savings are

$$(250 \times .70 \times 260 \times 94 \times .5) = 2.14 \text{ million km}$$

$$15 \text{ litres}/100 \text{ km} = 321{,}000 \text{ litres/year}$$

* 5% discount rate applied to reflect real capital cost net of inflation.

## 4.9 STAGGERED, FLEXIBLE HOURS AND COMPRESSED WORK WEEK

In the preliminary analysis it was estimated that flexible or staggered work hours might save up to 74,000 litres per year if 28% of the employment in the downtown participated in a flexible staggered work hour program. The estimated savings in energy would be derived as a result of improved travel time for auto users. Additional benefits could accrue to the transit system because peak demands would be spread over a longer period of time.

It was further estimated in the preliminary analysis that a compressed work week (e.g. four day work week versus a five day work week) could result in up to one million litres of fuel saved annually if 10% of the total employment in the study area participated.

Based on cost estimates of between $25,000 and $75,000 annually to promote an altered work schedule, the cost per litre saved would be in the range of 2 to 14 cents.

This is potentially a very cost-effective measure. However, the extent to which the estimated benefits can be achieved is a function of the extent to which any of the concepts may now already be in practice and, for those companies not already operating with an altered work schedule, and the companies' willingness to institute a new working arrangement for their employees. For these reasons, a survey was undertaken of the major employers within the study area to acquire a more definitive understanding of the potential for the measure.

The following provides a summary of the survey and its findings, and a refined estimate of potential benefits and estimated costs.

### Survey of Employers

Two surveys were used to derive employer and employee information on staggered, flexible hours and compressed work weeks. The first was undertaken primarily to address the potential for carpool marketing services in the area. However, this survey did provide valuable information on hours of operation for the large employers in the area who represented some 47,000

employees in total. The second survey was more specifically focused on flexible, staggered hours or a compressed work week. The latter survey provided a means of summarizing information by firm, number of employees, plant and office characteristics, current work hours, and potential for an alternate work schedule as perceived by the employer.

With respect to the first survey, the results of which are summarized in Exhibit 4.7.2, it is evident that, of the 47,000 employees involved in the survey, over 25,000 are at any one time working between 7:00 a.m. and 4:30 p.m. The remaining 22,000 employees are split almost equally between an afternoon shift and a night shift.

This work shift structure in Hamilton has had certain transportation implications, the most notable of which is the spreading of worker demand over a greater number of periods; in itself a form of staggered work hours.

A subsequent survey was undertaken to identify more specifically the extent to which flexible, staggered or compressed work hours are presently applied and also what employer interest there may be in adopting such concepts. The results of the survey are summarized in Exhibit 4.9.1. In preparing this summary a distinction was made between office and plant employees because it was found from the survey that many office employees are on flexible or staggered work hours already whereas plant employees are not as well suited to flexible hours but may be suited to compressed work weeks. The exhibit also summarizes reasons for fixed hour operations and also any potential for altering work hours.

As evident from Exhibit 4.9.1, a number of the office employees are on flexible or variable work hours; of the 13,000 employees surveyed, over 8,000 do not work a fixed schedule. It is also important to note that all of the larger offices surveyed (i.e. offices with more than 500 employees) have adopted a flexible or staggered work hour program.

Of those companies that are on a fixed work schedule, six companies have not considered an alternate work schedule, or require their office staff to work the same hours as plant staff. Two companies felt the concept would result in inefficiencies.

EXHIBIT 4.9.1

SUMMARY OF EMPLOYER SURVEY

| COMPANY | OFFICE | | | | | PLANT | | | | | | | | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Existing Work Hours | Reason: If Fixed Hours | | | | Existing Work Hours | Reason: If Fixed Hours | | | | | | |
| | No.of Employees | Variable Flexible Fixed | Not Considered | Need Same Time As Plant/Office | Ineffecient | No.of Employees | Variable Compressed Fixed | Not Considered | 24 Hr. Operation | Work in Groups (Assembly Line) | Union Decision | Sudden Or Custom Orders | Interested In Experimenting | |
| COMPANY A | 210 | F | | ✓ | | 650 | F | ✓ | | | | | | |
| COMPANY B | 500 | F | | ✓ | | 500 | F | | ✓ | | | | | compressed possible in some cases |
| COMPANY C | | | | | | | | | | | | | | |
| (D) | 500 | F | ✓ | | | | | | | | | | | |
| (P) | | S | | | | 2200 | F | ✓ | | | | | | |
| COMPANY D | 100 | F | | | ✓ | 400 | F | ✓ | | | ✓ | | | compressed possible |
| COMPANY E | 100 | F | ✓ | | | 300 | F | ✓ | | | ✓ | | | compressed feasible |
| COMPANY F | 125 | F | ✓ | | | 325 | F | ✓ | | | ✓ | | | have to be need for union consideration |
| COMPANY G | 175 | F | | ✓ | | 200 | F | | | | | ✓ | | |
| COMPANY H | | F/S | | ✓ | | 175 | F | ✓ | ✓ | | | | | if whole dept. agrees they do |
| COMPANY I | 115 | FL | | | | 310 | F | ✓ | | | | | | |
| COMPANY J | 132 | FL | | | | 1885 | F | ✓ | | | | | | possible |
| COMPANY K | 140 | F | ✓ | | | 760 | F | | | | ✓ | | ✓ | paintworkers inter. |
| COMPANY L | 500 | S | | | | | | | | | | | | |
| | 400 | FL | | | | | | | | | | | | |
| COMPANY M | 4000 | FL | | | | 1000 | F/C | | | | | | ✓ | exp. with 12hr.shifts |
| COMPANY N | 50 | F | ✓ | | | 775 | F | | | | | | | |
| COMPANY O (D) | 1580 | FL | | | | | | | | | | | | |
| (P) | 2340 | F | | ✓ | | 12735 | F | | ✓ | | | | | |
| COMPANY P | 190 | F | | ✓ | | 230 | F | | | ✓ | | ✓ | | |
| COMPANY Q | 250 | F | | | ✓ | 825 | F | | ✓ | | | | | |
| COMPANY R | 500 | FL | | | | 1200 | F | | | ✓ | | | ✓ | 4th crew -7day wk.wk. 4 days off |
| TOTAL | 13100 | | | | | 33470 | | | | | | | 46570 | |

Hours

C - Compressed
FL - Flexible
F - Fixed
S - Staggered

(D) - Office Downtown
(P) - Plant Office
(Assumed the same if not shown otherwise)

As for the plants, virtually all of the plants operate on a fixed work schedule. The majority of the plants had not considered an altered work schedule arrangement. Where an altered work schedule may have been considered it was considered inappropriate because of: the nature of the operation (e.g. 24 hour operation, assembly line); customer requirements; and union reluctance. It is important to note that a number of the companies indicated that compressed work weeks could be possible.

Based on the survey of employers, it would seem reasonable to conclude:

- A number of companies, especially the larger companies, have adopted a flexible or staggered work hour arrangement for office staff. The concept is ideally suited to larger companies but it would also have potential application for companies with over, say 50, office staff. However, these companies may have some reluctance to enter into such a program because of concern regarding disruption it may cause to the functioning of the office.

- Flexible or staggered work hours are not generally considered appropriate for plant operations. However, a number of companies have expressed some interest in the concept of a compressed work week with one company actually experimenting with a 12 hour shift. One of the major difficulties with compressed work weeks is limited experience, and the difficulty this might pose between unions and management, especially in larger companies. For this reason, a third party agency promoting the concept might be able to achieve more significant results than relying on either unions or the companies to institute a program.

Estimate of Benefits

Based on the findings of the survey, the greatest potential for energy savings would be through the promotion and assistance of a compressed work week with the major employers. From those employers surveyed, it was indicated that eight companies representing some 15,000 employees would consider compressed work weeks possible. Based on the assumption that 50% of the employees of the firms that expressed some interest in the concept of compressed work hours would eventually participate in a program, it was esti-

mated that annual fuel savings would range from 400,000 litres per year, assuming that a nine day work schedule was adopted for every two week period, to 800,000 litres saved per year if a four day work schedule in five week days were adopted. To some extent, these estimates might be considered conservative in that they do not include the potential for the concept to apply to other companies who were either non-committal in the survey or who were not surveyed. If it were determined from the initial applications of the compressed work week that there were important benefits of the altered work schedule to both the company and the employees, it is conceivable that the concept could become quite wide spread. The critical point is that the initial applications would have to be successful and properly evaluated. Moreover, a successful application would provide an important model for subsequent promotion of the concept to other employers and employees.

## Costs

In the United States, flexible and staggered hours or compressed work weeks have been promoted through ride-sharing offices as part of a transportation management program. As part of the program, major employers are approached and presented with various types of background information on the potential benefits to the employers, the employees and the community at large of flexible, staggered hours or compressed work weeks. If the employer is interested in the concept the employees of the ride-sharing office then prepare a program for the company which may include presentations to the union and employees, the establishment of an advisory committee, the preparation of promotional materials, the development of a timing program by department for the implementation and an evaluation program. Because staggered, flexible work hours and compressed work weeks once established do not require any on-going maintenance, the service is primarily one of assisting with the implementation. For this reason, it may be appropriate to combine these services through, for example, the services of a carpool marketing service e.g. ride-sharing office. This reduces overhead costs and it generally makes more efficient use of staff.

The estimated annual costs of a variable work hours program are $80,000 based on $53,700 for staff, $12,500 for promotional materials and

$10,000 for general expenses. The staffing costs assume that 3 people (i.e. 2 variable work hour advisors and 1 clerk) would be available half-time. (These costs could be reduced if combined with car and vanpool promotions).

Based on the estimated energy savings of a compressed work week costs would range between 10 and 20 cents per litre saved.

### Operational Responsibility

At present no single agency within Hamilton has the responsibility for promoting flexible or staggered hours or compressed work week. Because of the nature of the service it would be most appropriately provided through a ride-sharing office which promotes carpooling and vanpooling so that there is no duplication of effort when dealing with major employers.

### Conclusions

Because of the potential energy savings (based on only 5% of the total labour force in Hamilton adopting a compressed work week) and because the cost per litre of fuel saved ranges between 10 and 20 cents, a compressed work week program should be considered to test the degree to which these and additional benefits can be achieved. The Region should pursue the implementation of this measure through discussions with the MTC.

## 4.10 IMPROVED FACILITIES FOR LOW ENERGY VEHICLES

Low energy vehicles as defined here represent bicycles. This section presents a more detailed evaluation of potential bicycle usage and auto diversion potential than the initial appraisal. The evaluation limits itself to utilitarian trip purposes, since these are the trip purposes from which automobile diversion will most likely occur. This analysis investigates potential bicycle corridors in more detail.

### Methodology

In order to calculate bicycle trips on a zonal basis, both an estimate of population by age group and bicycle trip frequency factors are

required. For purpose of this analysis, the 1980 assessment data for the City of Hamilton was used to determine the population by age group in each planning district of the city. Information on average monthly trip rates for cyclists in various age categories was obtained from U.S. data, principally based on studies in Pennsylvania and Washington. This data was used for bicycle trip forecasts in the City of Toronto and is felt to be reasonably representative for use in this study. Using the current population data and the trip rates mentioned above, bicycle trips by planning zone were estimated. These estimates resulted in approximately 370,000 annual trips in the lower city and approximately 230,000 annual bicycle trips on the Mountain. The Mountain represents a formidable barrier to bicycle travel, and the effect of the Mountain on bicycle trip making had to be factored into the estimates. To estimate the proportion of trips crossing the escarpment to the total trips made in the lower city and on the Mountain, the 1986 peak hour person trip table was employed. It was found that a majority of the person trips that originated in the lower city stayed in the lower city. The calculations indicated that approximately 88% of the peak hour person trips with origins in the lower city had destinations in the lower city. The situation on the Mountain was substantially different. It was found there that in the peak hour 37% of the trips that had origins on the Mountain also had destinations on the Mountain. This has substantial implications on the amount of bicycle usage on the lower as opposed to the upper part of the City. Finally, an allowance in the bicycle trip generation was made for the percentage of trips that were divertible. Candidates for diversion from auto to bicycle we assumed to fall in the over 19 years of age category. The proportion of bicycle trips made for utilitarian purposes in the over 19 category represented 37% of the total bicycle trips. Using the above-mentioned factors and information, calculations on potential fuel savings in the corridor were conducted.

Corridors

Bicycle corridors selection in Hamilton was based on several factors. First, a major factor was the number of utilitarian bicycle trips generated per year in the planning districts or combinations of planning districts. Obviously, where the number of annual bicycle trips was very high, those areas were candidates for special bicycle facilities. Second, it was

important that the corridors have at least one major generator in them which could have been the downtown, university, a community college or a shopping centre. The ideal length of a utilitarian bicycle corridor is approximately 6.4 kilometres. Because cyclists prefer to travel in as direct a line as possible between origin and destination, typical corridor widths for bicycle travel seldom exceed 1.2 kilometres. Since utilitarian trips do tend to cluster in terms of time peaking, it is prudent to think in terms of the provision of exclusive space on an existing street. The three major corridors are described below:

East Gate (East Hamilton - Lower City)

This area is generally bounded by the CNR on the north the CBD on the west, the TH & B on the south and the Centennial Parkway on the east. The area in question includes the city's planning districts 6400, 6500 and 6600. The area has a potential for generating an estimated 270,000 annual utilitarian bicycle trips and has the CBD at the western end of the corridor and Eastgate Square at the eastern end of the corridor. The corridor is relatively long at 9.6 kilometres in length. A typical street that might be considered for use as a bicycle route would be Dunsmure Road. This is a long, continuous street from the east end of the corridor to the vicinity of the CBD at the west end of the corridor. There would be a short section of the route near the downtown that would result in a certain discontinuity. Here, the route, might operate on Holton, Wilson, Ashley and then approach the downtown on King William. There are several other continuous east-west streets in the corridor, however they tend to be major one way arterial streets. Dunsmure is a two way street and might absorb two 1.5 km designated bicycle lanes. This would necessitate removal of parking (which is fairly extensive on Dunsmure) and the possible reorientation of stop signs along the route. Based on a diversion rate somewhat lower than the 37% mentioned previously (i.e. 25%) and calculating that the average diversion would represent one half the corridor length it is estimated that there is a potential to save 248,000 vehicle kilometres of travel annually. This relates to approximately a 35,000 litre fuel saving potential in the corridor.

McMaster (Lower City West Hamilton)

This corridor is bounded by the CBD on the east, York Blvd. on the north, McMaster University on the west and the escarpment on the south. The corridor is estimated to contain 90,000 annual utilitarian bicycle trips. The corridor itself is approximately 6.4 kilometres long but has a major travel barrier - Highway 403 - which serves the corridor at its mid-point. In addition, the major continuous east-west streets crossing the barrier are King and Main which are very heavily travelled one way streets. Finding a usable route in the corridor would be very difficult task indeed. Some consideration might be given to the use of streets in the south side of the corridor such as Charlton and possibly Herkimer which would connect into the downtown via McNab and Bay Streets and might cross Highway 403 using Longwood Road. The routes would then proceed to McMaster via King Street. The diversion in this corridor might save approximately 72,000 kilometres of travel per year which represents approximately 38,000 litres of fuel saved.

Mountain Route

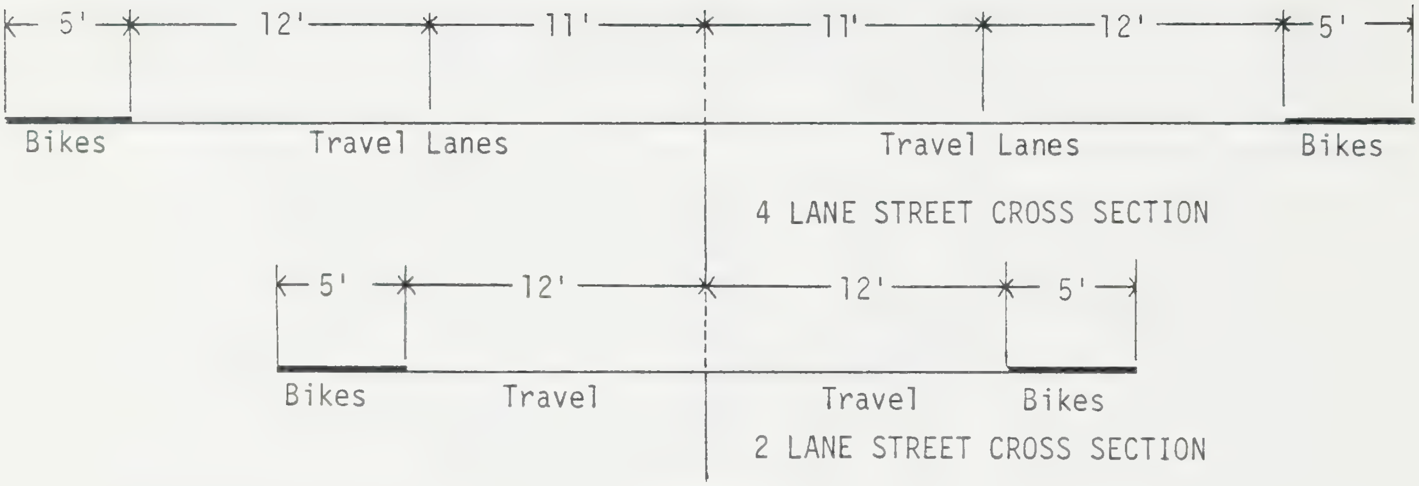
The mountain route could be centered on Fennell or possibly Brucedale and represents a corridor of approximately 7.2 kilometres long. The corridor would be bound by the escarpment on the east, the escarpment on the north, Garth Street on the west and Mohawk on the south. There are approximately 71,000 utilitarian bicycle trips annually in the corridor which would feature Mohawk College as the corridor anchor on the west end. Based on a 25% potential diversion factor, approximately 64,000 vehicle kilometres of auto travel might be saved at the corridor. This would represent approximately 9,000 litres of fuel saved.

Costs

As illustrated in Exhibit 4.10.1 bicycle lane costs are approximately $12,500 per kilometre, exclusive of contingency. Therefore the 23.2 kilometres of bicycle routes examined would cost approximately $350,000 (including a 20% contingency factor). It is anticipated that the economic life of the bicycle facilities would be between 5 and 7 years.

EXHIBIT 4.10.1

COSTS FOR BICYCLE LANES




Costs are for two - five feet wide lanes.

| | | WITH PARKING METERS | WITHOUT PARKING METERS |
|---|---|---|---|
| 1. | Remove Parking Meters | $ 8,100 | - |
| 2. | Modify Catch Basins | $ 6,500 | $ 6,500 |
| 3. | Route Signing | $ 650 | $ 650 |
| 4. | Slurry Seal Coat | $ 3,000 | $ 3,000 |
| 5. | Bike Route Stencil | $ 2,300 | $ 2,300 |
| Cost Per Mile | | $20,550 | $12,450 |
| Cost Per Km. | | $12,500 | $ 7,600 |

Exhibit 4.10.2 summarizes the implication of developing bicycle facilities as an energy saving strategy. The Exhibit indicates that there would be an annual fuel savings of 54,000 litres. Annual costs of the program are $50,000 and therefore the cost per litre saved is approximately $1.10.

## MAJOR IMPACTS

The development of bicycle lanes or routes effectuate changes in the transportation status quo. While previous sections of the "Improved Facilities for Low Energy Vehicles" describe potential routes and their impact on travel patterns, this section will deal with the implications of implementing bicycle lanes or routes in each corridor.

In the lower city - East Hamilton corridor there would be several impacts. First, on-street parking would have to be removed since this is an area of very high residential parking demand, replacement parking would have to be found. The removal of on-street parking might result in an increase in auto travel related to parking depending upon the location of the replacement parking. In order to develop a continuous route on which cyclists can operate, it had been recommended above that there be some consideration given to rotating stop signs in order to allow a cyclist a longer non-stop run. The corollary to this is that there may also be an increase in vehicle speeds and volumes on the street containing the bike route as a direct result of the rotation of stop signs. This is a site-specific problem that may not be acceptable to residents along the route. The diversion route is also intersected by a number of significant arterial streets. A number of these are unsignalized and if they remain so - would present a situation in which sufficiently frequent suitable gaps may not occur. This could have a direct impact on the number of accidents.

The lower city - McMaster corridor presents two problems. The first problem, mentioned earlier, is the difficulty in crossing the Highway 403 barrier using an existing structure. The second problem is the effective penetration of the downtown with a bike route.

## EXHIBIT 4.10.2

## SUMMARY OF SAVINGS

| | |
|---|---|
| Annual Fuel Savings | 54,000 L |
| Capital Cost of Facilities | $350,000 |
| Operating and Maintenance Costs | - |
| Economic Life | 5-7 Years |
| Average Annual Cost (Current Budget) | $ 60,000 |
| Cost Per Litre Saved | $1.10 |

The Mountain corridor would have to operate as a bike route as opposed to a bike lane because of restricted arterial widths - i.e. Fennell is a tight lane road now with no parking on it. Brucedale does hold some promise because of its continuity, but a safe connection to Mohawk College at its western and is problematic.

## Conclusions

Although there is a relatively high potential number of cycling trips to be made, there is a combination of factors that results in a relatively low divertibility rate. These factors include the presence of the escarpment as a barrier to trip making and the reduced frequency of utilitarian cycling trips in the auto driver age grouping. In addition, there are some physical and operational constraints that auger against the development of a utilitarian bikeway network.

Based on the detailed analysis, a bikeway system is not cost-effective in terms of energy conservation and other factors and therefore is not recommended for implementation. Bikeways might be considered for other reasons such as a recreational facility.

# 5 - EVALUATION OF MEASURES

The ten measures analyzed in Chapter 4 were evaluated using the following criteria:

- Potential energy savings - in analyzing each of the measures, the total annual potential litres of fuel saved were estimated. In some cases, especially the traffic related measures, the area-wide estimates were based on site-specific analysis expanded to reflect application to a number of sites. In other cases, annual energy savings were derived directly. For comparative purposes, an estimate was developed of the percent reduction in area wide fuel consumption. For this, a base area wide consumption per year of 650 million litres was used - 715 million litres discounted for the cold start adjustment factor* which was not used in assessing each of the individual measures;

- Cost per litre of fuel saved - the cost per litre of fuel saved per year was calculated based on the estimated annual fuel savings and the annual cost of implementing the measure. With some measures, a capital cost is incurred in which case the cost was annualized based on a 5% discount rate to reflect real capital costs (discounted for inflation). This capital cost was added to annual operating costs to derive a total cost per year. Where appropriate, traffic accident costs were also included based on an estimated average cost of $5,500 per accident;

- Safety - although accident costs have been included, where appropriate, in estimating the cost per litre of fuel saved, safety was considered an additional factor because it is not always possible to identify the full social costs of accidents especially if they involve personal injury. For this reason added weight is given to safety by this additional measure;

- Interaction with other measures - where measures would have a major impact on other measures, this was identified. The extent and type of interaction has an important impact on the development of programs.

* Source: "Traffic Management of Measures to Reduce Energy Consumption", prepared by IBI Group for TEMP, Nov. 1981

Air pollution was not included as a specific evaluation criteria because the air quality impacts of a measure are generally the same as energy impacts (i.e. as energy consumption decreases emissions decrease).

Based on the above criteria and the detailed analysis, Exhibit 5.1 was prepared. From the Exhibit, it is evident that the total potential savings per year of all of the measures is approximately 12 million litres per year or 2% of the base energy consumption. However, not all measures are cost-effective as reflected by the cost per litre of fuel saved. For example, the estimated cost per litre of fuel saved when stop signs are replaced with yield signs is \$.64 to \$1.88 including accident costs. Based on the summary information in Exhibit 5.1, the following measures are recommended for inclusion as part of a transportation energy management program for the Region of Hamilton-Wentworth:

- <u>Alternative traffic signal timing plans</u> - this measure provides the largest single possible energy savings - approximately 4 million litres per year. In addition, it is the single-most cost-effective measure with the cost per litre of fuel saved being less than 1¢ per litre. In addition, the measure will not have any detrimental effect on safety and could be implemented quickly and efficiently as the traffic signal operations are under the control of one department. The measure could be applied at all interconnected traffic signals;

- <u>Traffic signal coordination/actuation</u> - this measure would save an estimated 1 million litres of fuel per year at a cost per litre of between 1¢ and 2¢. The measure would not have any detectable impact on other measures and could be implemented easily given adequate capital funds. It is estimated that the measure could be implemented at 30 intersections;

- <u>Replace four way stops with traffic signals</u> - this measure would result in approximately 300,000 litres of fuel being saved annually and a cost per litre saved of 12¢. In addition, the analysis indicated that there is no appreciable difference in accident rates between four way stops and traffic signals. Generally, there is little difficulty in implementing traffic signals subject to meeting signal warrants. It is estimated that there are 10 locations where the measure could be implemented;

EXHIBIT 5.1

SUMMARY OF DETAILED ANALYSIS

| MEASURE | ENERGY SAVINGS TOTAL (litres/yr) | ENERGY SAVINGS % REDUCTION (area wide) | COST PER LITRE OF FUEL SAVED | SAFETY IMPACTS | INTERACTION WITH OTHER MEASURES |
|---|---|---|---|---|---|
| 1. Alternative Signal Timing Plans | 4,000,000 | 0.61 | $0.002 | Negligible | Negligible |
| 2. Traffic Signal Flashing | 155,000 | 0.02 | $.26 to $.39 (including accidents) | Significant Increase in Accidents | Negligible |
| 3. Signal Coordination/Actuation | 1,000,000 | 0.15 | $.014 Actuation<br>$.024 Coordination | - Minor Reduction in Collisions | Negligible<br>Should be in conjunction with 1. |
| 4. Replace Stop Signs With Yield Signs | 3,800,000 | 0.58 | $.64 to $1.88 (including accidents) | Additional 440 Accidents/Year | Negligible |
| 5. Replace 4-Way Stops With Traffic Signals | 300,000 | 0.05 | $.12 | Negligible | Negligible |
| 6. Express Bus Service | 180,000 | 0.02 | $0.37 | Negligible | Negligible |
| 7. Additional Promotion of Carpooling and Vanpooling | Phase 1<br>777,200<br>Phase 2<br>1,120,000 | 0.12<br><br>0.17 | $0.28<br><br>$0.24 | Negligible | Fringe Parking<br>Flexible, Staggered Hours |
| 8. Fringe Parking Lots | 321,000 | 0.05 | $0.19<br>$0.23 | Negligible | Carpooling and Vanpooling |
| 9. Flexible, Staggered Hours or Compressed Work Week | 400,000<br>800,000 | 0.06<br>0.12 | $0.20<br>$0.10 | Negligible | Carpooling and Vanpooling |
| 10. Improved Facilities for Low Energy Vehicles | 54,000 | 0.01 | $1.10 | Possible Increase | Negligible |

- Express bus service - although the express bus service would not result in large energy savings as compared to the other measures, express bus service could result in other benefits (e.g. reduced parking demand) and the cost per litre of fuel saved is within reason. Moreover, additional express bus service would serve to enhance the general image of public transit. Although only one route is considered feasible in the short-term, it is likely that as the service becomes accepted. It could be implemented on a number of major corridors;

- Additional promotion of carpools and vanpooling - this measure is recommended because of the potential energy savings which range from approximately 777,000 litres per year initially through to something in excess of 1.1 million with a mature program. Moreover, the cost per litre of fuel saved is in the range of 24¢ to 28¢ and there are significant other benefits such as reduced air pollution, reduced travel costs etc. Because the measure would have a significant degree of interaction with fringe parking lots and altered work schedules, it would be important that the program be coordinated with these measures. Moreover, there would be an opportunity in Hamilton to combine these three measures with a ride sharing office that could, over the longer term, provide a broad range of innovative services (taxi pooling, bus pooling, etc.). It should be pointed out that the estimated benefits for this measure were by design conservative because of the limited experience of the concept in Canada;

- Fringe parking lots - this measure would result in an estimated 320,000 litres of fuel saved at a cost per litre saving of between 19¢ and 23¢. This measure has potential interaction with additional promotion of carpooling and vanpooling and as such should be promoted in a joint fashion;

- Flexible, staggered hours or compressed work week - this measure has a potential to save between 400,000 and 800,000 litres of fuel a year at a cost per litre saving of between 10¢ and 20¢. This estimate is based on the adoption of a compressed work week by approximately 5% of the labour force in Hamilton. This was considered a conservative estimate based on the results of the employers' survey but it was considered appropriate given the required cooperation that would be necessary between unions and management in successfully implementing the measure. Because of the complementary nature, especially in terms of staff utilization, this measure should be combined with the additional promotion of carpooling and vanpooling to form a ride sharing office which initially would focus on promotion of carpooling and vanpooling and altered work schedules.

The above measures are recommended on the basis of potential energy savings and the associated costs. Many of the other measures analyzed, but not considered appropriate from an energy standpoint, may be justified for other reasons.

The measures not recommended for a transportation energy management program for the region include:

- <u>Traffic signal flashing</u> - this measure is not recommended because of the impact on accidents and the cost per litre of fuel saved - the latter including accident costs;

- <u>Replacement of stop signs with yield signs</u> - this measure will potentially saved 3.8 million litres of fuel per year. However, the cost per litre of fuel saved is between 68¢ and $1.88 per litre saved when the accident costs are included. It is important to point out that the accident information was based on an analysis of 24 intersections that were converted from yield to stop control. Although the accident analysis for these intersections indicated a significant increase in accident rate, it is possible that accident rates might not increase at certain intersections because of site-specific geometric and volume characteristics. Although this measure is not recommended as part of a broad transportation energy management program, it would be important that the energy impacts in a future installation of stop signs be considered at each site;

- <u>Improved facilities for low energy vehicles</u> - this measure is not recommended because of the high cost per litre of fuel saved and the low overall potential of energy savings. However, bikeways do serve other important functions, namely recreation. If bikeways could be justified for other reasons the energy savings would be a bonus.

Two other measures that are recommended but which were not considered in the detailed evaluation are pedestrian actuated signals and a promotional program to encourage the grouping of trips. From the preliminary analysis it was indicated that the pedestrian actuated signals measure would save an estimated 12,000 litres per year at a cost of $.05 per litre saved. Although it does not provide large savings it should be implemented as part of the regular traffic engineering program.

As for an educational program to encourage the grouping of trips this is a measure which requires more research. It is, however, potentially effective and might be considered by the Province as a research project.

# 6 - IMPLEMENTATION PROGRAM

Based on the measures recommended in Chapter 5 an implementation schedule of the recommended measures is presented in Exhibit 6.1. The exhibit includes an estimated schedule for each measure, and an estimate of capital and operating costs for each measure.

As per the exhibit, the Traffic Department acting on behalf of the City and Region would have responsibility for a large number of measures. Two of the measures - replacing isolated signals with coordinated actuated signals and replacing four-way stops with traffic signals - are capital programs that would have total costs of between $500,000 and $600,000. Annual operating costs for these measures have not been identified specifically because they would generally fall within the regular operating budget of the City and Region. Implementation of these measures is proposed to extend over a two year period. Each measure should be monitored on a site specific basis.

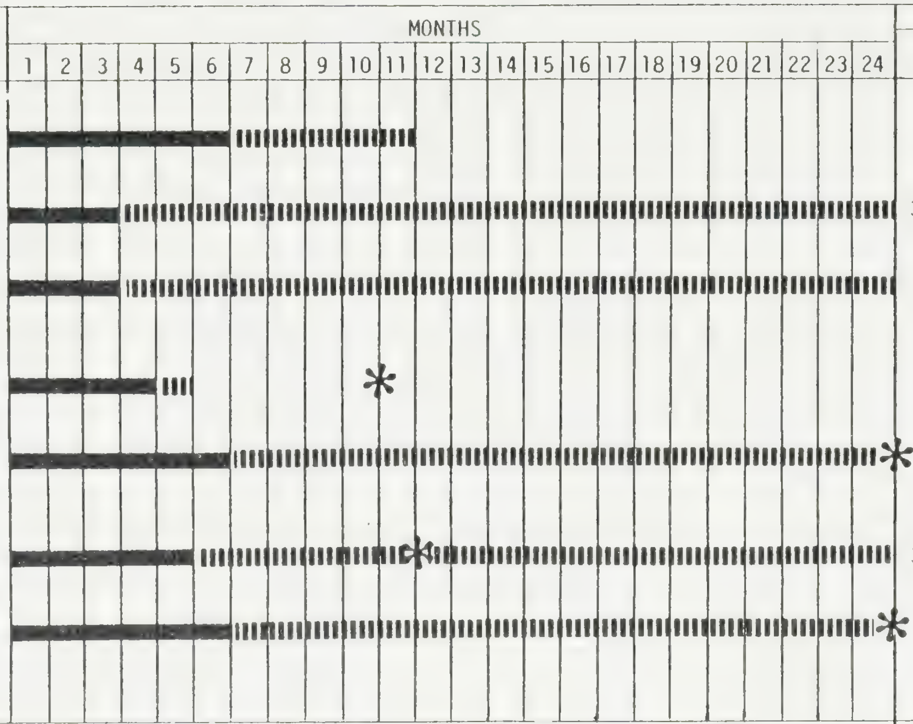
It should be pointed out that these recommendations on traffic operations measures are based on traffic signal coordination/actuation at 30 intersections, replacing four-way stops with traffic signals at 10 intersections and installing pedestrian actuated control at 10 intersections. Before programs are finalized and equipment ordered, each location should be analyzed in some detail to confirm the sites suitability and energy savings.

The other recommended measure for the Region is that of alternative signal timing plans. It is estimated that the total costs of developing new signal timing plans for all three time periods for all of the traffic signals would be in the range of $30,000. The alternative signal timing plan measure could be fully completed including implementation in an eleven month period which would include a six month period of data collection and analysis and five months to implement and evaluate.

An additional measure that is not shown in Exhibit 6.1 is pedestrian actuated signals. This measure could be implemented by the Traffic Department as part of a regular program of signal improvements.

EXHIBIT 6.1

IMPLEMENTATION SCHEDULE




| TRANSPORTATION MEASURE | COSTS: CAPITAL START-UP | COSTS: OPERATING (ANNUAL) | FUEL SAVINGS (LITRES) | COST PER LITRE SAVED |
|---|---|---|---|---|
| Alternative Signal Timing Plans | 30,000 | -(1) | 4,000,000 | $0.002 |
| Signal Coordination/Actuation | 300,000-400,000 | -(1) | 1,000,000 | $.01 to $.02 |
| Replace Four-Way Stop Signs With Signals | 200,000 | -(1) | 300,000 | $.12 |
| Express Bus Service | 15,000 | -(2) | 180,000 | $.37 |
| Additional Promotion of Carpooling and Vanpooling | 35,000 | 215,000 | 777,000 to 1,100,000 | $.24 to $.28 |
| Fringe Parking Lots | 300,000-375,000 | 25,000 | 321,000 | $.17 to $.23 |
| Flexible, Staggered Hours or Compressed Work Week | - | 80,000(3) | 400,000 to 800,000 | $.10 to $.20 |
| TOTAL | $880,000 - $1,055,000 | $320,000 | $6.98 - $7.7 Mil. | $0.002 to $.37 |

LEGEND:

Initial Planning

Implementation

Monitoring/Evaluation

NOTES:

1. No on-going operating costs.
2. Assumed as part of regular HSR operating budget.
3. If combined with promotion of carpooling and vanpooling this cost could be reduced significantly.

The express bus measure has an estimated cost of $15,000 for a start-up which would include detailed planning (development of trip schedules, etc.) and promotional material to introduce the service. This assumes that HSR has existing vehicles that could be allocated to the service and that once implemented all operating costs would be treated in the same fashion as other transit services. It is estimated that the initial start-up activities would require approximately four to five months. It would be appropriate to undertake subsequent evaluation of the impact six months after the measure is implemented.

The fringe parking lot program would have significant capital costs - $300,000 - $375,000. Because of these costs, it is recommended that fringe parking lots be instituted over the next two years but, where appropriate, arrangements be made to lease existing lots where such are conveniently located.

Implementation of additional promotion of carpooling and vanpooling and flexible, staggered hours or compressed work week could form a ride sharing office. In this way, there would be the opportunity to achieve staff efficiencies because of the similar nature of the activities (i.e. meeting employers and employees). The implementation schedule illustrates that a six month initial planning period would be required during which time software modifications could be made to the matching program and promotional and marketing materials developed. The actual implementation schedule would run over an eighteen month period, at the end of which, a detailed evaluation of the projects' benefits and impacts would be prepared and provide a basis for decision regarding subsequent continuation of the project.

The Region should approach the Ministry of Transportation and Communications with a view to joint participation in a number of the recommended measures including: additional Promotion of Carpooling and Vanpooling; implementation of Fringe Parking lots; and Flexible Staggered Hours or Compressed Work Week. The Region might also request of the MTC that they undertake further research in the area of an educational program to encourage the grouping of trips.

# APPENDIX A

# APPENDIX A

## ESTIMATE OF FUEL CONSUMPTION IN THE HAMILTON-WENTWORTH REGION

### Purpose

To estimate the total fuel consumption in the Region of Hamilton-Wentworth. This figure can then be used as a basis from which to assess the relative magnitude of fuel savings offered by the various alternatives.

### Method

Using a modified version of equation 1 developed by Cambridge Systematics, Inc. for the U.S. Department of Energy[7] the base fleet fuel consumption was estimated using the Region's road mileages, volumes and observed speeds as inputs:

$$\underset{\text{(litres/year)}}{\text{Fuel Consumed}} = \underset{i=1}{\phantom{x}} (100.4 \quad D_i + 0.63 \quad T_i) \quad N_i \quad C_1 \quad C_2 \quad C_3 \quad C_4 \quad 1$$

where: $D_i$ = the total distance of each road type i in km

$T_i$ = the travel time in secs (i.e. the reciprical of the average speed on road type i multiplied by $D_i$)

$N_i$ = the average annual daily traffic for each road type i

$C_1$ = 365.25 (a factor to allow for the upgrading of AADT to yearly traffic)

$C_2$ = 1.220 (a factor applied to allow for increased fuel consumption rates due to cold starts)

$C_3$ = 0.9635 (a factor applied to allow for the improved fuel efficiency resulting from the automobile fleet change since 1979)

$C_4$ = 0.001 a constant of the equation

i = the various road classifications for each jurisdiction
e.g. Regional Roads (width and surface type)
Municipal Roads (urban/semi-urban/rural by arterial/collector/local)

The resulting fuel estimates based on equation 1 are summarized in Table 1, below.

TABLE 1: AUTOMOBILE/SMALL TRUCK FUEL CONSUMPTION IN HAMILTON REGION

| Road Authority | Fuel Estimate ('000,000's Litres) | % of fuel | km of Roadway | % of Total Roads |
|---|---|---|---|---|
| Province - Provincial Highways QEW, #403, 2,5,6,8,20 & 56 | 194.1 | 34.3 | 211.8 | 9.6 |
| Regional Roads | 234.5 | 41.4 | 540.0 | 24.3 |
| City of Hamilton | 95.8 | 16.9 | 723.5 | 32.6 |
| Town of Ancaster | 6.86 | 1.2 | 163.1 | 7.4 |
| Town of Dundas | 9.51 | 1.7 | 69.6 | 3.1 |
| Town of Stoney Creek | 13.0 | 2.3 | 168.2 | 7.6 |
| Township of Flamborough | 12.7 | 2.2 | 342.2 | 15.4 |
| | 566.5 | 100.0 | 2218. | 100.0 |

The results of this equation were then adjusted to incorporate additional fuel consumed by commercial trucks and buses. Estimates of the fuel consumed by trucks were based on U.S. census statistics[14] of fuel consumption and annual travel distances broken down by vehicle weight. The extra fuel consumed was then calculated based on the area's proportion of the trucks registered in Ontario multiplied by the difference between the annual fuel consumption per truck and the base rate predicted by equation 1. The aggregated truck statistics are shown in Table 2.

TABLE 2: COMPOSITION OF 1979 TRUCK FLEET

| | Medium | Light-Heavy | Heavy |
|---|---|---|---|
| Annual Distance Km | 19,630 | 19,650 | 56,280 |
| Fuel Economy 1/100 Km | 36.93 | 48.15 | 62.59 |

To include the additional fuel used in buses the statistics of 66,000 km/veh/yr and 52.0 litres/100 km[6] were used in fuel calculations. These two additional fuel volumes for trucks (114.3 million litres) and buses (35.8 million litres) were then used to increase the base equation estimate of 5666.6 million litres/yr. (The estimated fuel consumption not including cold starts is 654.7 million litres/yr. As fuel savings estimates were not adjusted for cold starts this figure was used as the basis for comparison in evaluating the individual measures.)

Data

The information used in this estimation procedure was collected from numerous sources including:

- road traffic volume estimates from Transportation and Traffic Engineering Handbook[1] updated proportionally with the number of registered vehicles (information from Encyclopedia American Annual[23], 1969 and 1981);

- average speeds were based on information and data from the Hamilton Speed and Delay Study[4], as well as three other resports dealing with observed average speeds; Energy Impacts of Urban Transportation Improvements[5], (freeway speeds), Metropolitan Toronto Area Transportation Energy Study[6] (rural and semi urban arterial speeds) and Analytic Procedures for Estimating Changes in Travel Demand and Fuel Consumption[7] (urban arterial speeds);

- road mileage by road type and jurisdiction was taken from the Urban Roads Needs Studies - Municipal Roads Systems Report[8] and 1978 Traffic Volumes on the Kings Highways and Secondary Highways[9];

- the cold start factor used to modify equation 1, was determined from several sources including Recommended Traffic Measures to Reduce Energy Consumption[10], Temperatures and Precipitation, Ontario[11] and 1979 Travel to Work Survey[12];

- truck fuel consumption and travel information was taken from Ontario Vehicle Registration[13] and CNG Fuel Systems Limited, U.S. Market Survey[14], while bus fuel consumption data was from reference 6;

- the passenger automobile fuel consumption equation was based on an equation found in reference 7, an average automobile fuel consumption rate was determined based on information provided in Passenger Car Fuel Consumption Surveys, Fall 1979, Winter 1980[15].

## Assumptions

Some of the critical assumptions made in this calculation procedure were:

- The average road speeds were taken from the literature or observed data (where available) and are shown in Table 3. The implicit assumption is that the use of these average speeds in equation 1 will provide a good approximation of what must be an entire range of operating speeds varying with time of day actual road traffic and individual road characteristics.

- Table 3 shows the assumed AADT's by road classification that were used in Equation 1.

- It was assumed that the Canadian automobile fleet has experienced an average increase in fuel efficiency somewhat short of the rate displayed in the U.S. A factor of 0.963 was therefore applied to the fuel consumption predicted by equation 1.

- Based on information from reference 14, it was estimated that the average Ontario passenger vehicle travels 14,000 km/yr and consumes 2394 litres/yr.

TABLE 3: REGIONAL ROAD CHARACTERISTICS

| | Kilometres Of Roadway | Traffic Volume (AADT) | Average Speed (km/Hr) |
|---|---|---|---|
| Prov. & Reg. Roads | 751.8 | 25,000-50,000 | 50-95 |
| Urban - Arterial | 3.6 | 18,000 | 30 |
| Collector | 104.1 | 4,500 | 35 |
| Local | 672.8 | 1,200 | 32 |
| Semi-Urban - Arterial | - | 13,000 | 43 |
| - Collector | 20.5 | 3,800 | 44 |
| - Local | 168.1 | 1,000 | 41 |
| Rural | 501.1 | 400 | 63 |

- Truck traffic is assumed to represent about 6% or road vehicle volumes.

- The factor calculated as the Hamilton Region share of Ontario's passenger vehicle mileage and truck/bus fuel consumption was 3.59%

- Several more broad and basic assumptions were required in order to estimate fuel consumption. These were:

    1. That vehicle migration, across the Region's boundaries is relatively balanced thereby offsetting problems encountered in the latter part of this method in which buses' and trucks' fuel consumption are assigned to the area.

    2. That the traffic composition is relatively stable and that figures from the 1979 U.S. census survey approximate well the characteristics of the 1981 Hamilton-Wentworth truck fleet.

3. Equation 1 was applied to all road traffic. In order to fairly assess the additional fuel consumption due to trucks and buses the fuel consumption per vehicle per year was decreased by a fuel volume equal to that used by an average passenger vehicle per year as calculated from Ontario wide statistics (i.e. 2394/pass veh/yr).

4. Commercial vehicles which are not classified as trucks (e.g. taxis, cars for hire, small vans, etc.) have similar fuel consumption characteristics of those passenger vehicles for which equation 1 applies.